# SEWAGE AND INDUSTRIAL WASTES

(Formerly Sewage Works Journal)

The JOURNAL of the FEDERATION OF SEWAGE WORKS ASSOCIATIONS

## *Special Features*

Sewage Disposal at Boston—Flaherty

Water Reclamation—Ludwig

Dairy Wastes Oxidation—Porges, et al.

Oil Emulsions—Milne, Pratt

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1950 Yearbook and Directory

MARCH, 1950—VOL. 22, No. 3

*Make Plans to Attend*

# TWENTY-THIRD ANNUAL MEETING

OF THE

# FEDERATION OF SEWAGE WORKS ASSOCIATIONS

IN CONJUNCTION WITH

MARYLAND-DELAWARE WATER AND SEWERAGE ASSOCIATION (SEWAGE WORKS SECTION)

AND

FEDERAL SEWAGE RESEARCH ASSOCIATION

STATLER HOTEL
WASHINGTON, D. C.

*October 9-12, 1950*

FEDERATION OF SEWAGE WORKS ASSOCIATIONS
325 ILLINOIS BUILDING CHAMPAIGN, ILLINOIS

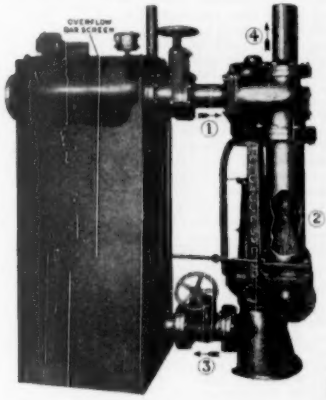
# CHICAGO" PUMPS

## FOR SEWAGE AND SLUDGE

### *FLUSH KLEEN EJECTORS FOR SEWAGE*

"Flush Kleen" pumps provide automatic, trouble-free service in sewage lift-stations. They require no manual attention except periodic lubrication and inspection. No labor is required for disassembling and cleaning clogged pumps as with other types.

The impellers handle only strained sewage. No solids pass through the impeller to cause excessive strain and wear on impeller, shaft, bearings or motor; pumps remain in balance and operate economically with little attention.

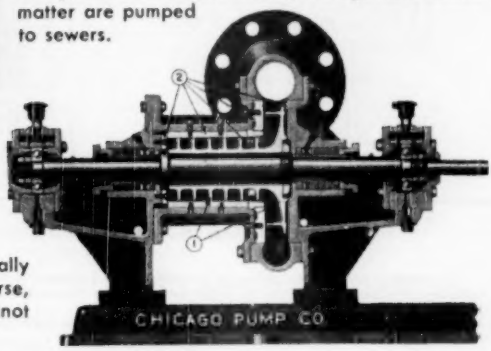



### Filling Wet Well

1. Sewage flows through inlet pipe.
2. Coarse matter is retained on strainer.
3. Strained sewage flows through idle pump to wet well.

### Pumping

3. Strained sewage is pumped from wet well.
2. Coarse matter is backwashed from strainer.
4. Special check valve closes; sewage and coarse matter are pumped to sewers.




### SCRU-PELLER PUMPS FOR SLUDGE

The Scru-Peller Pump was specifically designed to handle sludge. Coarse, stringy material is cut and cannot wrap or bind the impellers.

**1 SCREW and IMPELLER** are keyed on the shaft and held firmly against a shoulder on the shaft by a nut. The screw has two flights; and the impeller has two blades. Each flight in the conveyor connects directly with its own blade of the impeller.

**2 CUTTING EDGES.** There are four cutting bars and a cutting ring in the screw housing and four cutting bars in the pump casing. The cutting takes place between the edges of the screw and the cutting edges in the screw housing, between the edges of the impeller blades and the cutting edges in front of the impeller, and between the edges of the impeller blades on the back of the impeller and the cutting edges of the pump casing.

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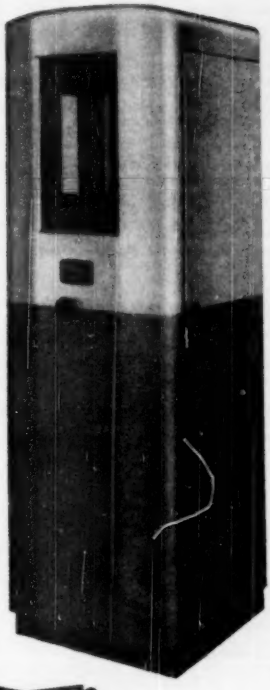

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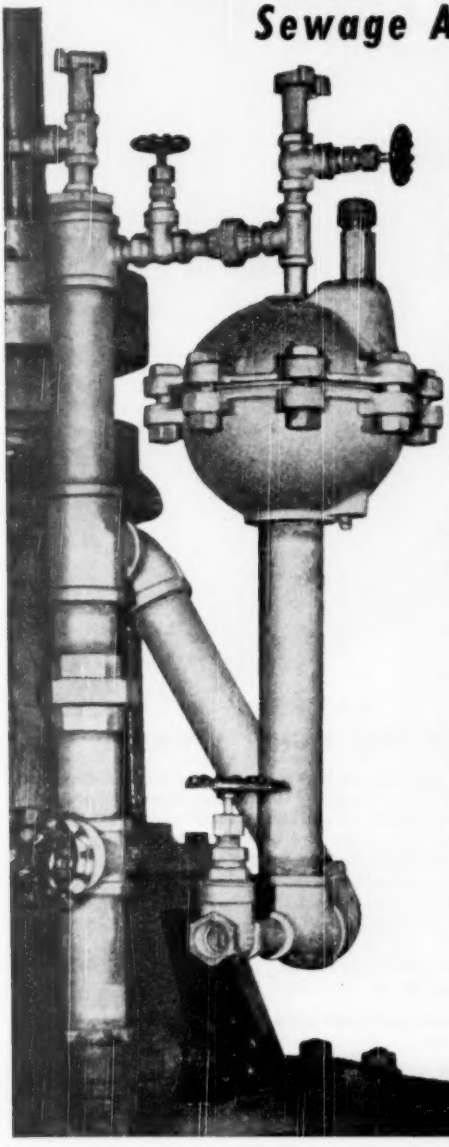
## Sewage Air Release Valve



. . . rids air accumulations automatically and frequently from pipe lines carrying sewage or other solid matter. By virtue of its construction this type of valve can be mounted on sewer lines or on sewage pump casings. Flushing and cleaning of the internal working parts of the valve can take place at any time when Simplex's Air Release Valve is equipped with an approved type back flushing device. For full information, write: Simplex Valve and Meter Co., 6719 Upland St., Philadelphia 42, Pa. *Ask for Bulletin 110.*

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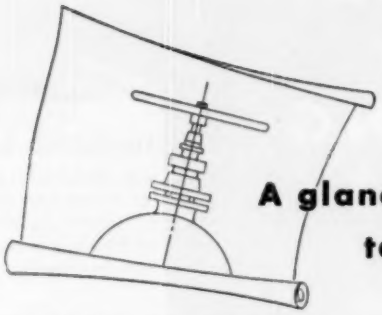

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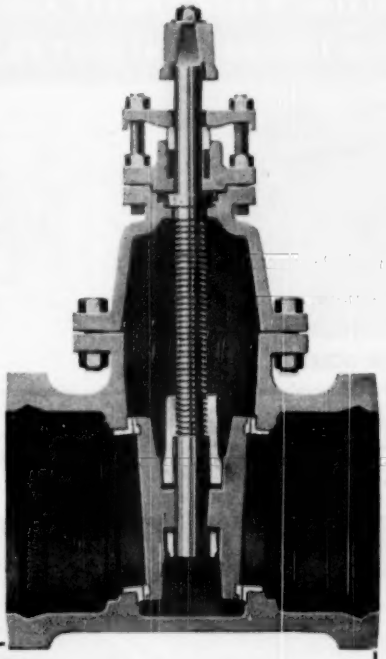

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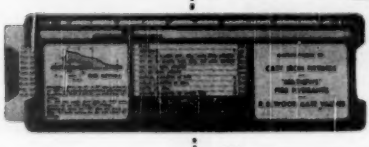

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*for*

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—for removal of floating solids over ½" in size, from incoming sewage or industrial liquids, thus assuring an even flow through the channel. Send for Folder No. 1587.

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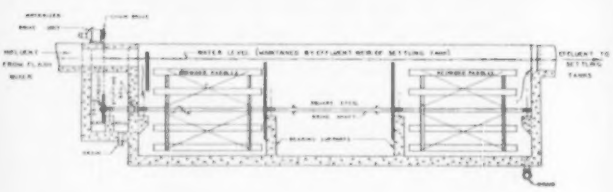
—are used for the removal of screenings and grit at small sewage treatment plants. With the Tritor Screen, one mechanism accomplishes removal of both grit and screenings. Send for Book No. 1587.



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—for rectangular tanks where horizontal flow is desired. The degree of mixing can be reduced as the water flows through the tank by decreasing the number and changing the pitch of the paddles. Send for Folder No. 2042.

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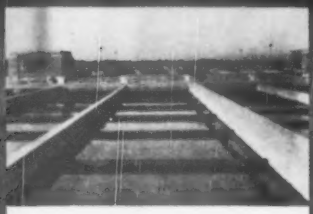

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—for rectangular settling tanks. Straightline Collectors with peak-cap bearings, pivoted flights and "Straightline" action provide a combination which can't be beat for efficient collection of sludge and grease. Send for Book No. 1742.

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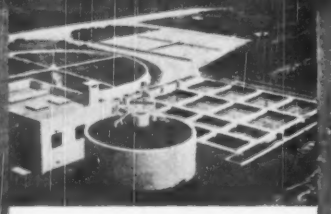

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This system consists of high rate shallow filters and recirculation of the effluent from the filter to the settling tanks. Features are: great flexibility, high rate of B.O.D. loading and the ability of plants to handle strong domestic and industrial sewage in single-stage or two-stage treatment, as required. Send for Folder No. 1881.

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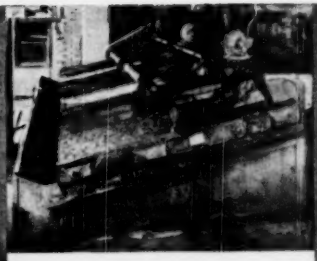

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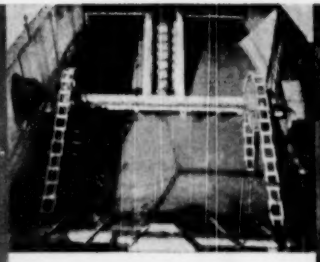

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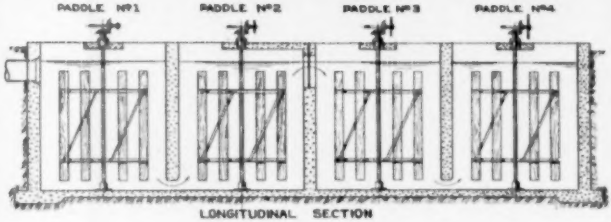


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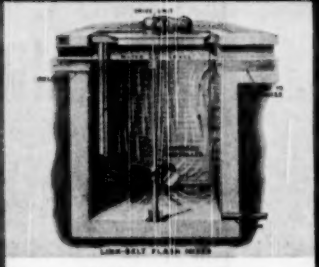

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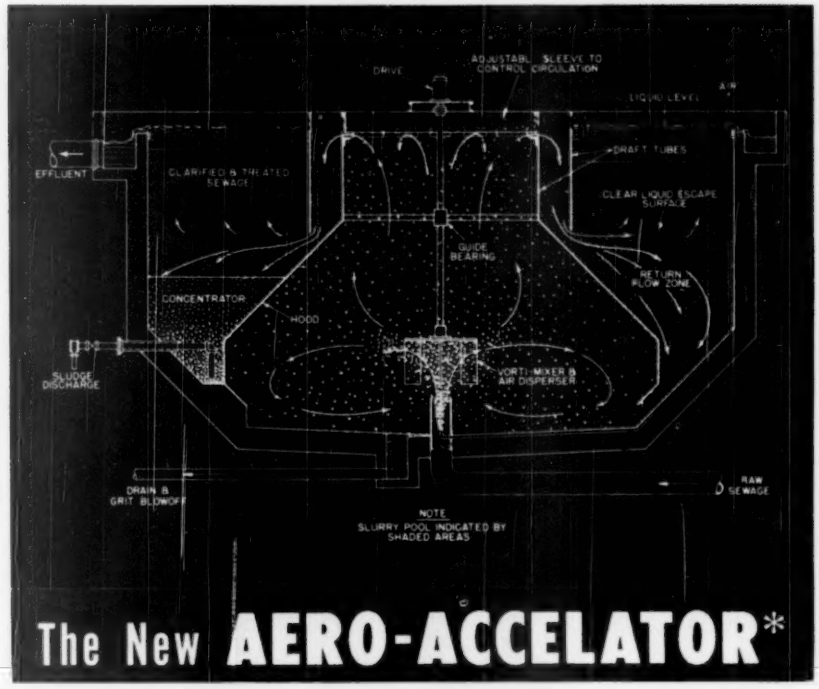


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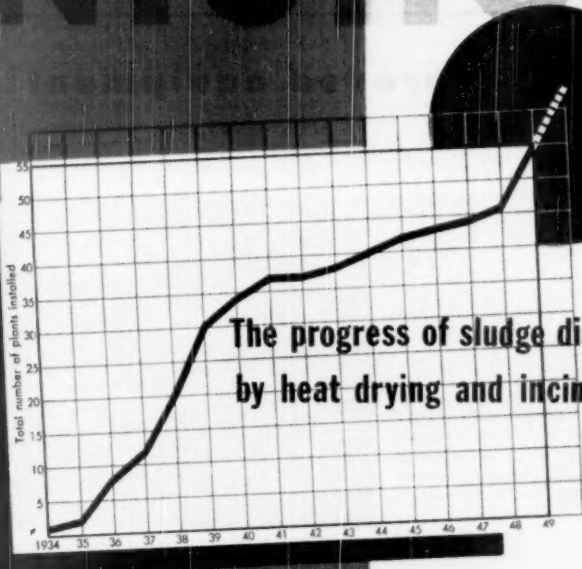


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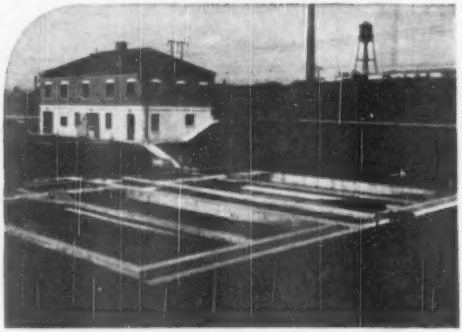

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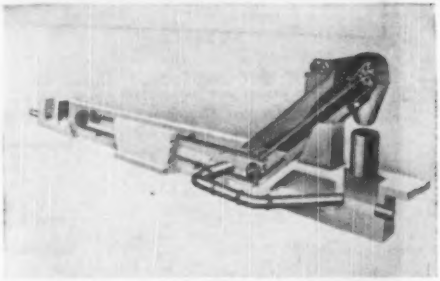

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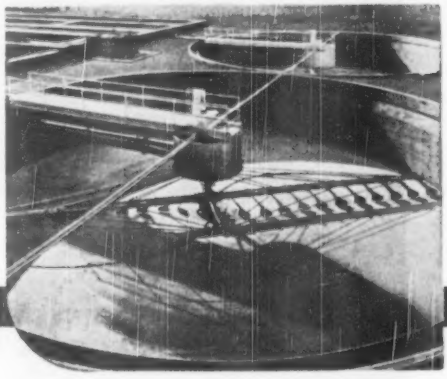

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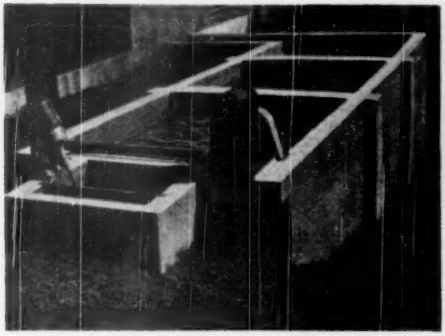

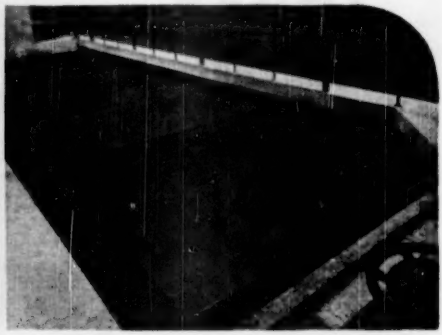

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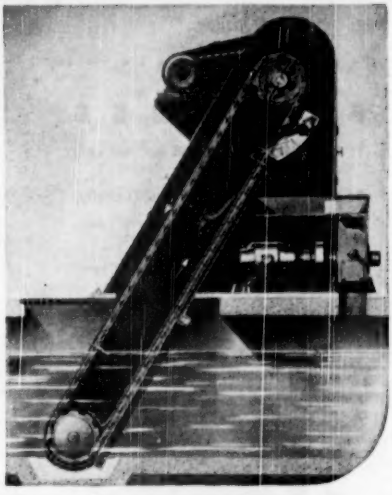

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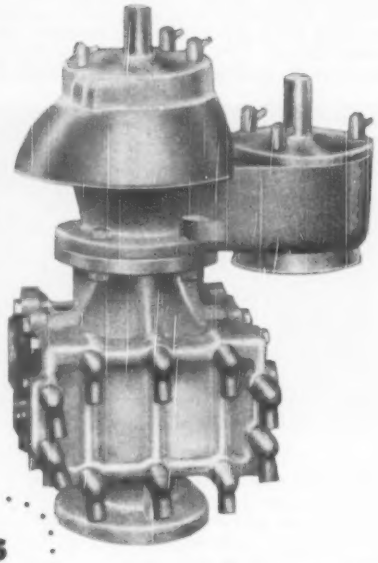

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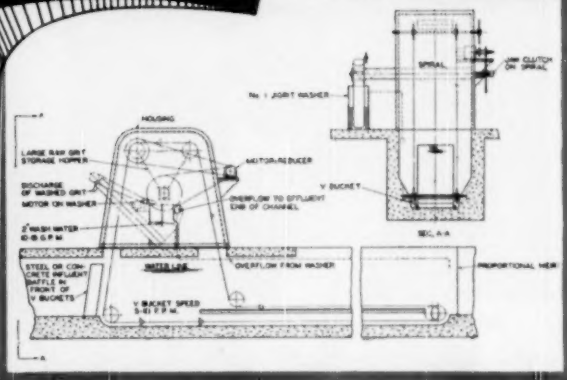


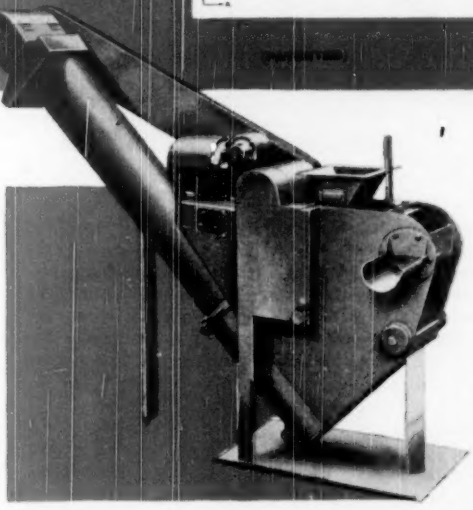

*Left* — Jeffrey "JIGRIT" No. 1 — a basket type jig for classifying and removing putrescible solids from sewage grit in plants of moderate size. Capacity — 20 cubic feet per hour. 90% recovery of inorganic grit. Produces a washed grit that can be used for fill or dumped anywhere without nuisance. Also No. 4 "JIGRIT" washer for washing grit at rate of 120 cubic feet per hour, and No. 9 for 280 cubic feet per hour . . in single units fully automatic in operation.

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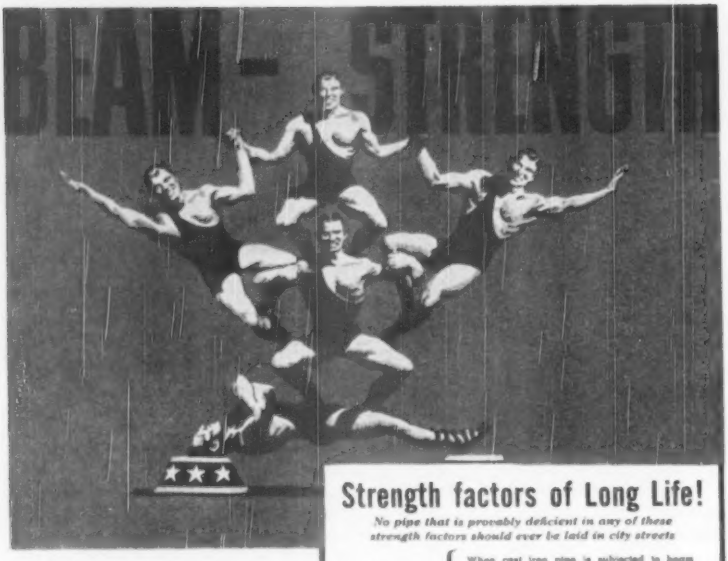


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# SEWAGE AND INDUSTRIAL WASTES

*The Journal of the Federation of Sewage Works Associations*

**Volume 22** **MARCH, 1950** **Number 3**

## Contents

**Sewage Works**

Sewage Treatment and Disposal for Boston. By JOHN F. FLAHERTY ..... 277

Reclamation of Water from Sewage and Industrial Wastes in Los Angeles County. By RUSSELL G. LUDWIG ..... 289

Maintenance and Operation of Metropolitan Boston Sewers. By THOMAS A. BERRIGAN ..... 296

Discussion by WILLIAM P. GYATT ..... 303

Mechanical Equipment in Sewage Treatment. By FRANK L. FLOOD ..... 307

Discussion by CHARLES R. VELZY ..... 314

**Industrial Wastes**

Biochemical Oxidation of Dairy Wastes. I. Methods of Study. By NANDOR PORGES, JANET B. PEPINSKY, NANCY C. HENDLER, AND SAM R. HOOVER ..... 318

Character of Waste Oil Emulsions. By DAVID MILNE ..... 326

Extended Use of Oil Emulsions to Minimize Disposal Problems. By M. A. PRATT .. 331

The Effect of Chromium on the Methane Fermentation of Acetic Acid. By J. F. PAGANO, RUTH TEWELES, AND A. M. BUSWELL ..... 336

**Stream Pollution**

Bacterial Standards for Natural Waters. By ABEL WOLMAN ..... 346

Discussion by A. H. STEVENSON ..... 353

**The Operator's Corner**

Your Local Paper Can Help ..... 356

To Lime or Not To Lime ..... 357

From Activated Sludge to Activated Suds at Batavia, Ill. ..... 362

Starting the Operation of the Abington Township Sewage Treatment Plant. By R. M. BOLENIUS ..... 365

Heavy-Duty Rake for Dry Sand Filters. By N. C. AVERY ..... 371

Solving a Digester Scum Problem. By LEONARD HILLIS ..... 372

Tips and Quips ..... 373

**Editorial**

A Federation Fact of Life ..... 376

**1950 Federation Directory**

Officers, Awards, Meetings, and Committees ..... 377

Consolidated Membership List ..... 395

**Member Association Meetings** ..... 460

W. H. WISELY, *Editor*, 325 Illinois Building, Champaign, Illinois

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# Sewage Works

## SEWAGE TREATMENT AND DISPOSAL FOR BOSTON *

By John F. Flaherty

*Senior Civil Engineer, Boston Public Works Department, Sewer Division, Boston, Mass.*

As part of an extensive program for the abatement of pollution in Boston Harbor, the City of Boston has recently completed plans and specifications for a sewage treatment plant. Legislation enacted in July, 1949 authorized construction of a sewage treatment plant and appurtenant works for the Boston Main Drainage System. This act provided for financing by borrowing outside the statutory debt limit, through 30-yr. bond issues, a sum not to exceed $12,000,000, and made mandatory the start of construction prior to April 1, 1950, and completion before July 1, 1955. The treatment plant is estimated to cost approximately $8,000,000.

### Sewerage Systems

Before describing the proposed treatment plant and disposal works, a brief description of the Metropolitan Boston sewerage systems, as shown in Figure 1, is presented.

There are three major sewerage systems tributary to Boston Harbor. The North Metropolitan System, serving communities to the north of Boston, including the Charlestown and East Boston districts of Boston, discharges at Deer Island. The South Metropolitan System serves communities to the south and west of Boston and also the Brighton, Hyde Park, and parts of the Back Bay, Dorchester, West Roxbury, and Roxbury districts of Boston. It outlets off Nut Island. The Boston Drainage System serves Boston proper, South Boston, and parts of the Back Bay, Dorchester, Roxbury, and West Roxbury districts of Boston; also, the Squantum district of Quincy and areas in the town of Milton. This system discharges at Moon Island. The first two systems are under the jurisdiction of the Metropolitan District Commission, a state agency, whereas the latter is under the jurisdiction of the City of Boston.

### Boston Main Drainage System

The Boston Main Drainage System, shown in Figure 2, was designed as a combined sewerage system and intercepts the dry-weather flow and part of the storm run-off from areas not tributary to the Metropolitan systems. Combined flows in excess of the interceptor capacities are discharged through local overflows. District regulators are installed at some of the connections and tide gates are provided on all overflow conduits. This system serves an area of 11,500 acres, a resident population of 450,000, and a transient population of over 800,000, or an equivalent population of approximately 500,000.

The Main Drainage was constructed during the period from 1877 to 1888 and consists of over 27 mi. of intercepting sewers, chiefly of brick masonry, which flow by gravity to the

* Presented at 22nd Annual Meeting, Federation of Sewage Works Associations; Boston, Mass.; Oct. 17–20, 1949.

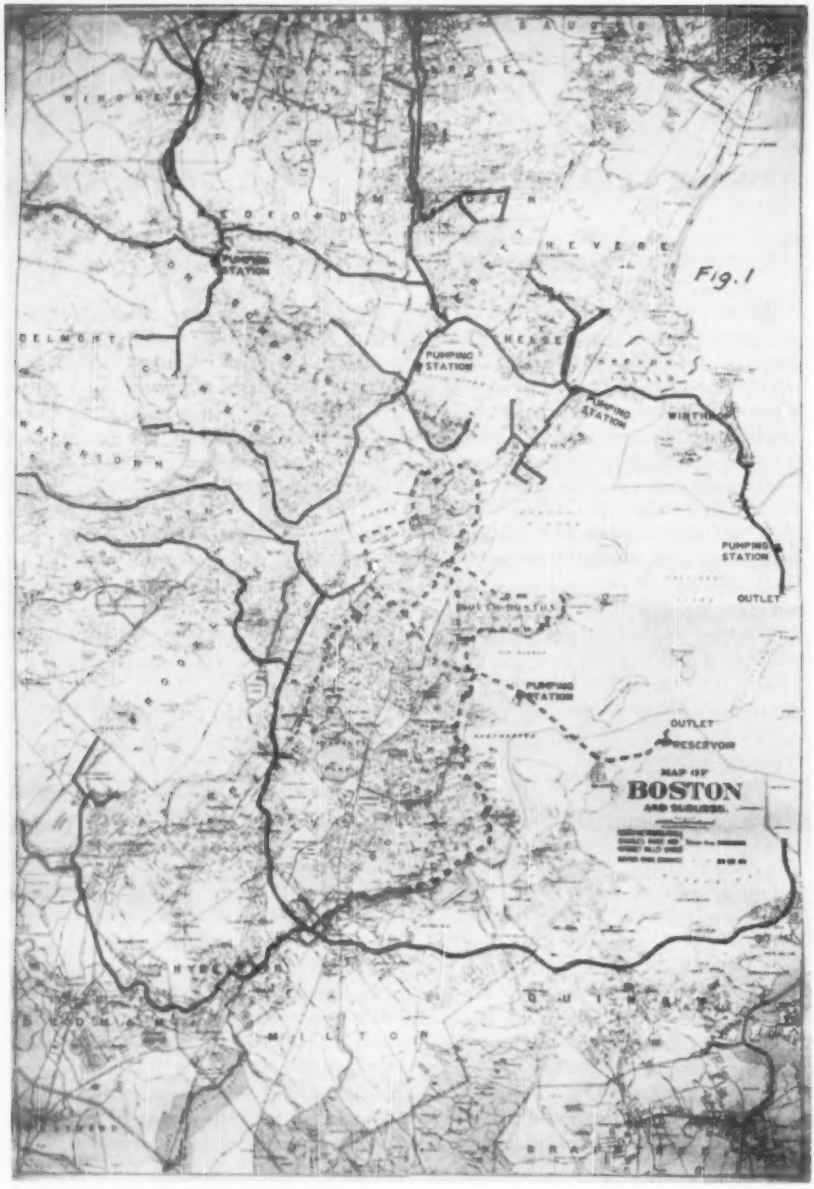


FIGURE 1.—Sewerage systems of Boston, Mass., area.

FIGURE 2.—Relation of Boston Main Drainage system to metropolitan area.

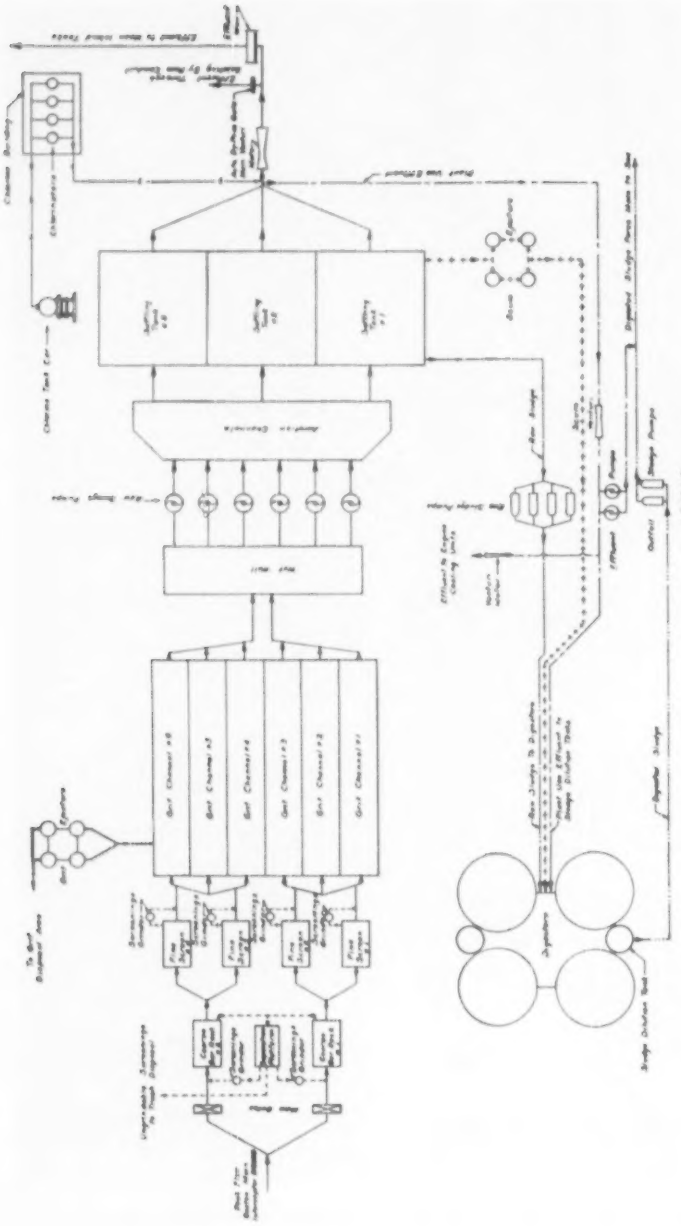

FIGURE 3.—Flow diagram of Calf Pasture sewage treatment plant.

Calf Pasture works. The main interceptor, 3.25 mi. long, and varying in size from 7 ft. 7 in. to 10 ft. 6 in. in diameter, carries the flow from five principal branch interceptors; namely, the South Boston interceptor, 5.25 mi. long, varying in size from 15 in. to 6 ft., which follows the shore line; the Dorchester interceptor, 6.6 mi. long, varying in size from 3 ft. to 5 ft., which follows the shore line and the north bank of the Neponset River; the East Side interceptor, 2.9 mi. long, sized from 15 in. to 5 ft. 8 in., which follows the north side of the Roxbury Canal and Fort Point Channel, thence along the waterfront; the West Side interceptor, 3.35 mi. long, varying in size from 15 in. to 5 ft. 6 in., which extends from the upper end of the main interceptor through the Back Bay section and along the south side of the Charles River Basin; and the Stony Brook interceptor, 4.0 mi. long, varying in size from 3 ft. to 4 ft. 8 in., which lies in the Stony Brook Valley. The disposal works of this system will be described later.

## Engineering Investigations

Earlier engineering investigations of the pollution problem in Boston Harbor (the most recent being those of the Special Commission of 1935, whose findings were reported under House No. 1600 of 1936; and the Engineers Report submitted by Metcalf and Eddy of Boston and Greeley and Hansen of Chicago, contained in House No. 2465 of 1939, and with which most sanitary engineers are familiar) arrived at the conclusion that, for the present, only primary treatment is required for sewage discharged into the harbor. The objectives to be accomplished are four —namely, to remove floating solids, which are unsightly on the harbor waters; to remove grease, which causes extensive sleek areas; to reduce the amount of suspended solids capable of forming sludge beds; and to prevent excessive bacterial pollution of the harbor and shore waters during the recreational season.

These objectives will be accomplished by incorporating in the proposed plant the following major units: coarse and fine bar racks, screenings grinders, grit chambers, aeration channels, sedimentation tanks, chlorination equipment, and sludge digestion and disposal facilities.

## Basic Data

A flow diagram of the proposed sewage treatment plant is shown in Figure 3 and the tentative design data were as follows:

| | |
|---|---|
| 1. Population | |
| (a) Design population, including equivalent for transients | 500,000 |
| (b) Area served | 18 sq. mi. |
| 2. Rate of sewage flow | |
| (a) Minimum | 27 m.g.d. |
| (b) Usual minimum | 40 m.g.d. |
| (c) Average dry weather | 74 m.g.d. |
| (d) Average flow, dry and wet weather | 85 m.g.d. |
| (e) Maximum dry weather | 110 m.g.d. |
| (f) Maximum storm flow | 212 m.g.d. |
| 3. Coarse screening | |
| (a) Clear openings | 4 in. |
| (b) Volume of rakings (at 0.02 c.f./cap./yr.) | 27 c.f.d. |
| 4. Mechanically cleaned screening | |
| (a) Clear openings | 1 in. |
| (b) Volume of rakings (at 0.2 c.f./cap./yr.) | 275 c.f.d. |
| 5. Screenings disposal | |
| (a) Grinders or shredders | 4,000 lb./hr. |

| | |
|---|---|
| 6. Grit removal | |
| (a) Detention period at average flow | 1 min. |
| (b) Velocity at average flow | 1 f.p.s. |
| (c) Volume of grit, average | 170 c.f.d. |
| (d) Volume of grit, maximum | 1,000 c.f.d. |
| 7. Grease separation by aeration | |
| (a) Detention period at average flow | 6 min. |
| (b) Air required (aeration rate 0.04 c.f./gal.) | 2,350 c.f.m. |
| (c) Aeration tank capacity | 47,500 c.f. |
| 8. Sewage sedimentation | |
| (a) Detention period at average flow | 90 min. |
| (b) Detention period at maximum flow | 36 min. |
| (c) Detention period at average dry weather flow | 103 min. |
| (d) Settling tank capacity | 710,000 c.f. |
| 9. Grease and scum removal | |
| (a) Quantity at 0.75 c.f.m.g. (dry basis) at av. flow | 63.5 c.f.d. |
| (b) Quantity at 85% moisture | 3,160 g.p.d. |
| 10. Solids and sludge balance | |
| (a) Estimated av. susp. sol. in raw sewage | 175 p.p.m. |
| (b) Total dry susp. sol. for av. flow | 124,000 lb./day |
| (c) Dry susp. sol. per cap. for 500,000 persons | 0.25 lb./day |
| (d) Estimated settling tank efficiency at average flow | 46% |
| (e) Av. dry susp. sol. removed | 57,000 lb./day |
| (f) Raw sludge removed from settling tanks at 95% moisture | 136,000 g.p.d. |
| (g) Estimated dry vol. content of raw sludge | 60% |
| (h) Dry vol. sol. in raw sludge | 34,000 lb./day |
| (i) Dry mineral sol. in raw sludge | 23,000 lb./day |
| (j) Reduction in vol. sol. by digestion (at 60%) | 20,200 lb./day |
| (k) Residual vol. sol. in dig. sludge | 13,800 lb./day |
| (l) Total dry sol. in dig. sludge | 36,800 lb./day |
| (m) Av. dig. sludge vol. at 93% moisture | 63,000 g.p.d. |
| (n) Av. dig. sludge vol. at 98% moisture | 220,000 g.p.d. |
| 11. Sludge digestion | |
| (a) Total capacity (at 0.9 c.f.c.) | 450,000 c.f. |
| (b) Capacity equiv. per lb. total solids | 7.9 c.f. |
| (c) Average time of digestion | 25 days |
| 12. Digested sludge disposal | |
| (a) Av. dig. sludge vol. at 98% moisture | 220,000 g.p.d. |
| (b) Assume all sludge discharged into sludge outfall in two 4-hr. periods, or a total of 8 hr. per day. Then average discharge rate | 660,000 g.p.d. or 460 g.p.m. |
| 13. Supernatant liquor | |
| (a) Estimated average quantity | 110,000 g.p.d. |
| 14. Gas production | |
| (a) Probable quantity per lb. of vol. sol. in raw sludge | 8.0–11.0 c.f. |
| (b) Population equiv. per capita | 0.54–0.74 c.f. |
| (c) Total gas production | 270,000 c.f.d. |
| (d) Total fuel value (at 640 B.t.u. per c.f.) | 173,000,000 B.t.u./day |
| 15. Gas utilization | |
| (a) Est. heat required, digestion tanks | 2,100,000 B.t.u./hr. |
| (b) Est. heat required, buildings | 700,000 B.t.u./hr. |
| (c) Est. heat available | 7,250,000 B.t.u./hr. |
| (d) Equiv. low heat value | 6,500,000 B.t.u./hr. |
| (e) Equiv. gas-engine power at 10,000 B.t.u./hr. | 650 b.h.p. |
| (f) Heat recoverable from jacket water | 2,000,000 B.t.u./hr. |
| (g) Heat recoverable from exhaust gas | 1,100,000 B.t.u./hr. |
| 16. Chlorination | |
| (a) Est. average chlorine demand | 10 p.p.m. |
| (b) Est. max. chlorine demand | 13 p.p.m. |
| (c) At average flow, average demand | 7,100 lb./day |
| (d) At average flow, maximum demand | 9,200 lb./day |
| (e) At peak flow, average demand | 17,700 lb./day |
| (f) At peak flow, maximum demand | 23,000 lb./day |
| (g) Provide four 6-ton chlorinators | |

### Proposed Treatment Plant

The proposed plant comprises influent controls, coarse and fine bar screens, and grit chambers located in a deep structure below the administration building; a pumping station, aeration channels, settling tanks, a chlorination building, spur tracks for chlorine tank cars, sludge digestion tanks and control house, high- and low-pressure gas holders, waste gas burners, a Venturi meter, and an effluent control chamber.

### Administration Building

The first floor of the administration building contains an operator's room, first aid room, locker room, wash room, lunch room, a 3-car garage, work shop, and storage room; also an equipment room housing the controls for the main sewage inlet gates and a gas-fired boiler. The second floor contains the chemist's room, specimen room, laboratory, and the plant superintendent's office.

### Screening and Grit Removal

The plant influent is regulated by two sluice gates 8 ft. square and automatically float controlled by hydraulic cylinders operated by compressed air. Auxiliary emergency operation is provided by secondary oil transfer pumps, which can be operated by electric motor or manually.

Two coarse bar screens, each 9 ft. wide and having 4-in. clear openings, are provided with mechanical cleaning by one traveling rake similar in design to that employed for cleaning trash racks at power plant intakes. The rakings will be sorted on a separation platform. The solid trash will be placed in buckets and carried to a nearby dump for disposal. The shreddable material will be fed to one of two grinders and returned to the flow.

Four mechanically-cleaned fine bar screens are provided, each 7 ft. 6 in. wide with clear openings of 1 in. The mechanism is designed for periodic operation with supplementary operation by float control, which will function in the event of excessive head loss through the screen. Screenings will be discharged to a grinder located behind each screen and the shredded material returned to the flow.

After screening, the flow enters six rectangular grit chambers, each 85 ft. long, 10 ft. wide, and having a high water depth of 8 ft. Grit will be collected from the channel bottoms by flight scrapers feeding to inclined screw conveyors and washers. Two belt conveyors will carry the washed grit to a group of four pneumatic ejectors, whence the grit will be blown through a pipe line for fill close to the plant site. At the downstream end of each grit chamber a Camp type regulator is provided for velocity control. Flow leaving the grit chambers passes through twin 6 ft. 4 in. square conduits to the pump house wet well.

The screening and grit removal facilities are installed ahead of the pumps, even though a considerable amount of deep excavation is required, for the following reasons: (a) the large quantity of trash and grit inherent to a combined system, (b) the frequent clogging of, and the extensive wear on the existing pumps, and (c) the importance and magnitude of pumping operations in this plant.

### Pumping Station

The proposed facilities for sewage pumping provide a considerable flexibility over a wide range of pumping rates. These units comprise four 70-m.g.d., one 30-m.g.d. and one 10-m.g.d. vertical centrifugal sewage pumps. Three of the 70-m.g.d. units are to be driven through right-angle gears by supercharged dual-fuel engines. These engines are rated at 750 hp. each and operate on either diesel oil or sludge gas or a mixture of both. Supercharged engines were selected in order to take advantage of the reduction in

weight and size as compared with the atmospherically charged engine and the increase in efficiency by turbo-charging. The dual-fuel engine speed will be automatically controlled from the wet well through governors. The fourth 70-m.g.d. pump, which will be motor driven, is to be used as a stand-by pumping unit and will be manually controlled only.

The 30-m.g.d. and 10-m.g.d. pumps are both to be motor driven and automatically float controlled to reduce the necessity for undesirable frequent variation in the operation of the dual-fuel engines.

The pump discharges have been provided with tapering discharge manifolds terminating in wide shallow outlets at the water line of the aeration channels.

Control equipment and gauges register all the information necessary for the coordination of plant operation at a main control center located on the engine room floor. The dual-fuel engines are controlled from operating panels located near each engine.

Two blowers, each of 3,400-c.f.m. capacity, one engine driven and one other motor driven, will supply compressed air to the swing diffusers located in the aeration channels. The blowers are of the rotary, positive displacement, two impeller type.

In the substructure below the engine room are located the pumps, engine auxiliary equipment, and heaters. In the galleries under the aeration channel are located the raw and digested sludge pumps, effluent pumps, and plant compressed air equipment.

Dual-fuel engine auxiliary units have been arranged to provide maximum sludge gas utilization. Engine jacket water and exhaust gases are used to supply heat for the digester heat exchangers and the building heating system. Boilers designed to burn either sludge gas or manufactured gas are provided to supply additional heat as required.

The right wing of the pumping station contains a fully equipped machine shop and an electricians' shop. The left wing houses the gas compressor room and a small chlorinator room for chlorinating the plant effluent used for engine jacket water cooling and other services.

### Aeration Channels

Aeration channels receive the pump discharge and provide an aeration period of 6 min. at average flow. They comprise a double channel each 12 ft. wide, having a water depth of 10 ft., with end-around flow for a total length of about 380 ft. Air will be supplied up to 3,400 c.f.m. through swing-type diffusers. Sewage flow from the aeration channels passes through influent channels designed to provide uniform distribution of flow into the settling tanks.

### Settling Tanks

Three settling tanks are provided, each 210 ft. long and 75 ft. wide, with a water depth of 15 ft., furnishing a detention period of over 1.5 hr. at average flow.

Raw sludge will be removed from the settling tanks by means of a traveling bridge crane with a hoist-operated blade for scraping the sludge to the influent end of the tank. The scraper blade will be raised to the surface on the return trip in order to convey the scum to the effluent end, where a cross collecting mechanism will deliver the scum to pneumatic ejectors for transfer to a scum receiving tank atop the digester control house. Scum may be delivered to the digesters, or into tank trucks if demand for a low grade grease arises. Sludge cross collectors at the influent end will concentrate the sludge in sumps for withdrawal by sludge pumps to the digesters.

It is to be noted from this description that equipment submerged in the settling tank flow has been held to a minimum. Repair work on the scraping mechanism may be performed in

the dry at the repair pit located between the aeration channels and settling tanks, without the necessity of dewatering the settling tanks.

Two Meider-type machines have been provided, with trackage arranged so that each unit may be operated in any one of the three tanks. Power will be furnished through a third-rail system. The traveling speeds will be approximately 2 ft. per min. while scraping sludge, and 10 ft. per min. while skimming.

Settling tank effluent, after chlorination, will pass through a Venturi meter into a control chamber, from which the sewage will be discharged into one of the existing deposit sewers for final disposal at Moon Island. An automatic by-pass sluice gate will discharge flows in excess of the tunnel capacity into the other deposit sewer for discharge into Dorchester Bay in the vicinity of the tunnel's west shaft.

Chlorine will be applied to the effluent through submerged diffusers at the settling tank outlet, and also at the aforementioned by-pass. Chlorination equipment includes five evaporators and five chlorinators, each rated at 6,000 lb. per day, and auxiliary equipment, including automatic program control.

## Sludge Digestion and Disposal

Four concrete tanks 75 ft. in diameter and 25 ft. deep at the sidewalls enclose a two-story control house. The lower story of the control house is connected to the pumping station by a large tunnel used for carrying piping as well as providing access for personnel.

The total digester capacity is 450,000 cu. ft., allowing about 0.9 cu. ft. per capita and a 25-day digestion period. Two-stage digestion is provided, with floating covers on the primary and gas-holder covers on the secondary tanks. Equipment is arranged for recirculation of the tank contents and for external sludge heat exchangers located in the control house.

Sludge gas production is conservatively estimated at 270,000 cu. ft. per day. Gas produced by digestion will be collected in the gas-holder covers on the secondary digesters and withdrawn to the low-pressure gas storage tanks for engine fuel or directly to the gas-fired boilers. Gas production in excess of current consumption will be stored in the high-pressure spherical tank to meet peak pumping demands. When storage capacity is exhausted, gas will be diverted to waste gas burners.

A unique feature is the provision of two 25-ft. diameter digested sludge storage tanks with mixers, in which digested sludge, withdrawn from the secondary digesters, will be brought to an optimum concentration for pumping through the sludge outfall force main.

A digested sludge force main, 19,000 ft. long and 8 in. in diameter (see Figure 4), will be laid from Calf Pasture under Dorchester Bay, across Thompson Island and under the harbor to Long Island, where it will connect with the 12-in. sludge outfall from the Metropolitan Nut Island plant for a joint discharge into President Roads.

## Selection of Plant Site

This paper would not be complete without some discussion of the relationship between the proposed treatment plant and the existing works—in particular, the factors that influenced the choice of plant site—and of the final disposal of the treated sewage.

The main interceptor, a circular 10 ft. 6 in. brick sewer, delivers all the sewage tributary to the Boston Main Drainage System to the Calf Pasture pumping station. Its invert is over 13 ft. below mean low water, so that no emergency by-pass to tide water is available, and all flows must be pumped.

FIGURE 4.—Location map of Calf Pasture treatment plant and sludge outfall lines.

At present the sewage, after passing through elevator-cage type screens, is lifted by motor-driven pumps about 35 ft. into twin 8 ft. by 16 ft. deposit sewers, 1,300 ft. long, and, after passing through these sewers for the purpose of grit removal, the sewage is carried under Dorchester Bay through a tunnel, which is an inverted siphon, brick lined, 7 ft. 6 in. in diameter and 7,160 ft. long. The lower portion of this siphon lies more than 140 ft. below mean low water for a distance of 6,090 ft. The tunnel discharges at Squantum, into an 11 ft. by 12 ft. outfall sewer 5,400 ft. long, built in embankment to Moon Island. Here the sewage is retained in storage basins having a working capacity of 40 m.g. and is discharged on the ebb tide at the easterly end of Moon Island.

In designing the proposed plant it was decided that a new pumping station at Calf Pasture was imperative, and that, for reasons previously mentioned, the racks and grit chambers should be located ahead of the pumps. The most important alternative involved the location of the settling tanks and sludge digesters on Moon Island or the location of these units at Calf Pasture.

Locating these structures at Moon Island had the obvious advantages in that it was more remote, thereby reducing considerably the possibility of odor complaints, and presented a much less difficult foundation problem. The Calf Pasture location presented the following advantages:

1. Discharge of settled and chlorinated sewage, instead of screened raw sewage, into Dorchester Bay, in event of interruption of the tunnel.
2. Improved capacity of the Dorchester Bay tunnel is anticipated when carrying settled rather than raw sewage. This is important, inasmuch as the tunnel is the limiting factor in the capacity of the discharge works.
3. Most effective utilization of sludge gas for pumping.
4. Consolidation of and convenient access for supervisory and operating personnel.
5. Availability of railroad siding for tank car delivery of chlorine instead of trucking to Moon Island.
6. An estimated $150,000 lower annual cost.

After consideration of the above factors the consulting engineers decided to locate all the works at Calf Pasture. The plant influent conduit will be connected to the main interceptor a short distance upstream from the existing screen house. The plant effluent conduit will be connected to the existing deposit sewers. The present pumping station will maintain the sewage flow until the new plant is in operation, and there will be practically no interruption of flow during the change-over.

### Final Disposal

The location of the plant is in close proximity to recreational areas, and the adoption of primary treatment indicated the desirability of retaining a remote point of discharge. Even if secondary treatment were employed, it is probable that the discharge of an effluent, regardless of its degree of treatment, in the vicinity of Calf Pasture would not meet with the approval of the public health authorities. It is not necessary to construct an extensive outfall to deep water, however, as there is available the existing disposal works, which provide both a remote outlet and favorable tidal currents.

Therefore, the existing deposit sewers will serve as chlorine contact chambers, one sewer delivering the flow to the Dorchester Bay tunnel, the other discharging storm flows, in excess of the tunnel capacity, at the West Shaft by-pass.

The tunnel, in periods outside the recreational season, may be by-passed, dewatered, inspected, and have necessary repairs effected, and methods devised to increase its capacity if possible. The outfall sewer will deliver the effluent to the Moon Island storage basins, from which the treated sewage will be discharged on the ebb tide. Although at present sewage usually is discharged only on the second and third hours of the ebb tide, it is probable that the increased pumping capacity provided in the proposed plant, and the anticipated increase in tunnel capacity, will require discharge over a longer period of the outgoing tide.

The ability to discharge on the ebb tide, thereby taking advantage of favorable tidal currents to carry the sewage field well down the harbor before the tide turns, is a disposal facility seldom provided at sewage outlets, which generally discharge continuously. This feature reduces considerably the possibility that the Moon Island outlet will require extension in the future.

In conclusion, after many years of study and planning, the City of Boston, a pioneer in sewerage works over 70 years ago, now moves forward to

improve the sanitary conditions of the waters of Boston Harbor by the construction of a modern sewage treatment plant.

### Acknowledgments

Planning for the program described herein was carried out under the direction of Commissioner of Public Works Robert P. Curley and Sewer Division Engineer Robert P. Shea. Plans and specifications for the sewage treatment facilities were prepared by Charles A. Maguire and Associates, Engineers, with Elson T. Killam as consultant.

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## CITY TO INSTALL HOUSEHOLD GARBAGE DISPOSERS

By its passage of two unprecedented ordinances on February 14, 1950, the city council of Jasper, Ind., made that community what is probably the first municipality in the world to adopt the electric household disposer as a substitute for the garbage can and collection truck. The first ordinance, enacted under permissive legislation passed in 1949 by the Indiana Legislature, suspends all municipal garbage collection after August 1, 1950, and accepts a bid to install electric garbage disposers in the sinks of Jasper householders. The second forbids the storage of garbage outside homes within the city limits after that date.

Reluctance of the present private garbage collectors to renew their contracts with the city caused city officials to explore the possibilities of the waterborne disposal of food wastes through the municipal sewer system and new sewage treatment plant. In an informal survey to determine whether Jasper citizens favored the mass installation of disposers, about 60 per cent registered approval. A majority of the city's householders already has filed application for the units. Those who have not yet filed applications have until June 1, 1950, to submit their orders. Under the plan, each individual householder will buy his disposer from the city.

It is estimated that the mass installation of disposers will save the city $13,000 annually in wages and equipment charges for garbage collection. At the same time it is expected to eliminate much of the fly, rodent, and stray animal nuisance associated with garbage cans, and thereby improve community health.

Rubbish collections, which are separate from garbage pick-up, will be continued. People not wishing disposer installations may dispose of garbage by incineration or other methods approved by the Board of Health. Any firm or person desiring to collect garbage will be licensed by the city; the vehicles must be approved by the city health officers and comply with city, county, and state health ordinances.

Under the terms of the contract accepted by the city council, installations of the disposers are to be completed not later than July 31, 1950.

# RECLAMATION OF WATER FROM SEWAGE AND INDUSTRIAL WASTES IN LOS ANGELES COUNTY

By Russell G. Ludwig

*Sanitary Engineer, Ludwig Bros. Engineers, Pasadena, Calif.*

The data summarized herein are abstracted from a report submitted in April, 1949, to the Los Angeles (Calif.) County Board of Supervisors by a joint Board of Engineers comprising A. M. Rawn, chief engineer and general manager of the County Sanitation Districts; H. E. Hedger, chief engineer of the County Flood Control District; and C. E. Arnold, county surveyor and engineer. The author, formerly a member of the County Sanitation Districts engineering staff was responsible for the detailed organization of the report.

## Introduction

It is desired first to point out some of the pertinent facts which gave impetus to this reclamation study in Los Angeles County. Although many know the importance of water to Southern California and its history of water importation from the Sierras and the Colorado River, few realize that the major source of water supply to Southern California is the local ground water. Due to the tremendous growth of population and industry in the past decade this ground-water supply has been developed to the ultimate and beyond, resulting in marked lowering of ground-water tables and serious salt water infiltration along the coastal margins.

In the minds of many people the apparent solution to this problem is the further use of imported water from the Colorado River. However, the situation is not that simple because:

1. All areas in Los Angeles County are not members of the Metropolitan Water District and therefore are not eligible for Colorado River water.

2. Even member areas are not assured of their ultimate needs, due to quota limitations determined by assessed valuation and allowable peak supplies.

3. Colorado River water is not as good in quality as most local natural ground waters.

4. The over-all cost of softened Colorado River water to the consumer is of the magnitude of $30 to $40 per acre-foot, considerably above the cost of local supplies where available.

For these reasons, ground-water levels continue to drop, because no consumer wants to trade his existing ground-water supply for a more expensive and generally less desirable imported supply. This complex picture led to the joint County water reclamation study, as it was recognized that in the reclamation of spent waters there was already available a raw-water supply which might immediately be used to alleviate the shortage. The purpose of the study was to bring to light the various factors affecting reclamation and to outline the ways and means of setting up an operational program. An over-all water plan, which will include in its scope any and all potential water sources, is currently being prepared for Los Angeles County. The recently completed study

will serve to place reclamation in its proper place in this plan.

## Water Reclamation as Related to Sewage Disposal

Of fundamental importance to the whole discussion is the simple statement that reclamation of sewage water is not new, but is as old as sewage disposal itself. Leaching from cesspools and septic tanks, and also the final disposal of sewage treatment plant effluents by irrigation or percolation, have actually constituted water reclamation. This is denoted in Figure 1 as water reclamation incidental to sewage disposal. Although such reclamation is the result of necessary sewage disposal, it is testimonial that such a process can be and has been accomplished within public health and public nuisance standards.

There are several significant reasons why a reclamation works built specifically to reclaim water and not burdened with sewage disposal responsibility could produce an end product of superior quality without ever causing an odor nuisance. Among these are:

1. Such a plant, unlike a sewage disposal plant, would not have to process all of the flow in the sewer line. It could draw off as much or as little as desired at any time.

2. The plant would not process sewage solids or skimmings, these materials being returned to the raw sewage line.

3. The plant could shut down at any time and return its entire flow to the sewer line.

In other words, a reclamation plant would have the necessary flexibility to provide a positive control on the final effluent quality. The value of a completed sewerage system in facilitating the development of a water reclamation program is clearly indicated by these factors. With such a system water reclamation could stand on its own feet and be a planned enterprise. Such a reclamation process is outlined in Figure 2.

## Proposed Reclamation Process

One of the important considerations leading to a successful reclamation program is the proper selection of a raw supply suitable for reclamation. Sewage from essentially residential and business areas will usually be suitable as is. For example, it is estimated that the water reclaimable from the sewage supply of the San Gabriel Valley area of Los Angeles County

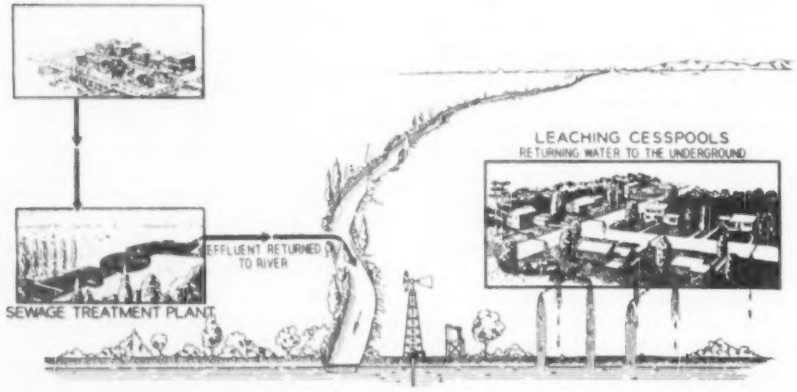


FIGURE 1.—Water reclamation incidental to sewage disposal.

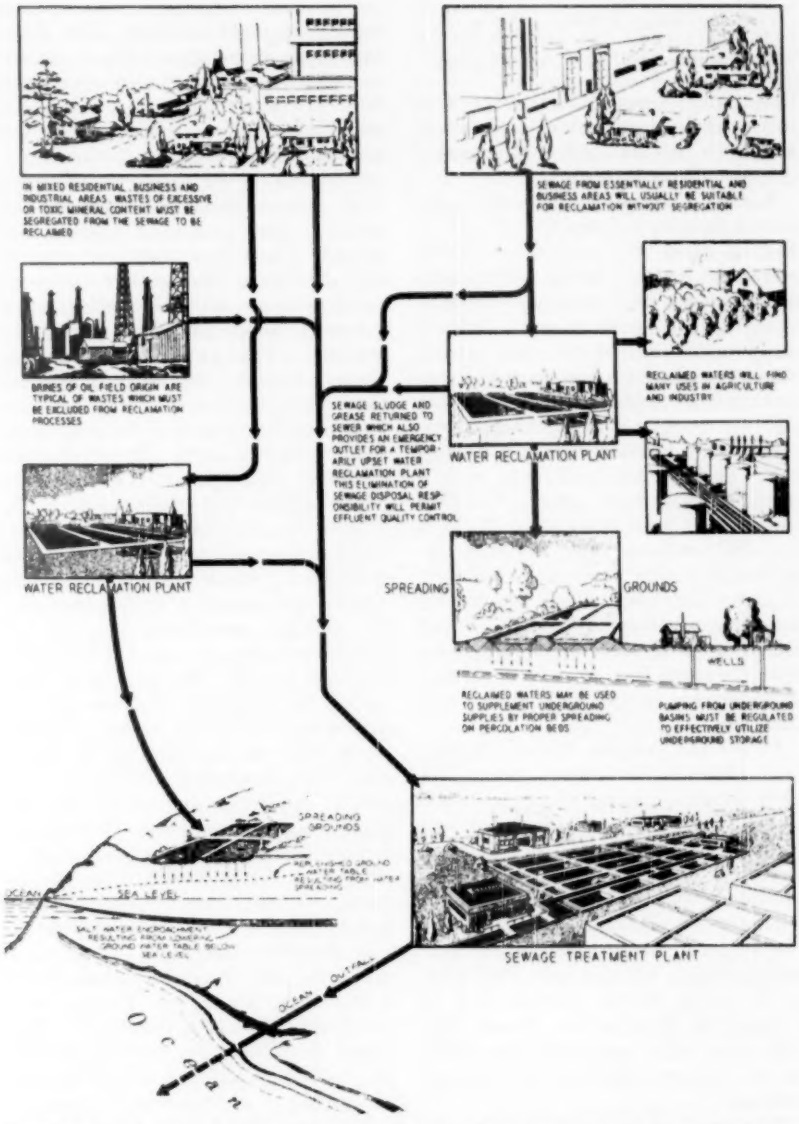
IN MIXED RESIDENTIAL, BUSINESS AND INDUSTRIAL AREAS, WASTES OF EXCESSIVE OR TOXIC MINERAL CONTENT MUST BE SEGREGATED FROM THE SEWAGE TO BE RECLAIMED
SEWAGE FROM ESSENTIALLY RESIDENTIAL AND BUSINESS AREAS WILL USUALLY BE SUITABLE FOR RECLAMATION WITHOUT SEGREGATION
BRINES OF OIL FIELD ORIGIN ARE TYPICAL OF WASTES WHICH MUST BE EXCLUDED FROM RECLAMATION PROCESSES
RECLAIMED WATERS WILL FIND MANY USES IN AGRICULTURE AND INDUSTRY
SEWAGE SLUDGE AND GREASE RETURNED TO SEWER WHICH ALSO PROVIDES AN EMERGENCY OUTLET FOR A TEMPORARILY UPSET WATER RECLAMATION PLANT. THIS ELIMINATION OF SEWAGE DISPOSAL RESPONSIBILITY WILL PERMIT EFFLUENT QUALITY CONTROL
WATER RECLAMATION PLANT
WATER RECLAMATION PLANT
SPREADING GROUNDS
WELLS
RECLAIMED WATERS MAY BE USED TO SUPPLEMENT UNDERGROUND SUPPLIES BY PROPER SPREADING ON PERCOLATION BEDS
PUMPING FROM UNDERGROUND BASINS MUST BE REGULATED TO EFFECTIVELY UTILIZE UNDERGROUND STORAGE
SPREADING GROUNDS
SEA LEVEL
SALT WATER ENCROACHMENT RESULTING FROM LOWERING GROUND WATER TABLE BELOW SEA LEVEL
OCEAN OUTFALL
OCEAN
SEWAGE TREATMENT PLANT

FIGURE 2.—Water reclamation as a planned enterprise separated from sewage disposal.

would have the following characteristics:

| | |
|---|---|
| Total diss. mineral solids | 710 p.p.m. |
| Chlorides | 130 p.p.m. |
| Total hardness | 184 p.p.m. |

This water compares favorably with many natural local ground waters and with both raw and softened imported Colorado River water.

Sewage and industrial waste composites from mixed residential and industrial areas will usually have to be segregated and the better quality supply selected. At first glance this may seem to be a hopeless task. Critical study indicates, however, that usually the segregation of a few wastes of concentrated mineral content may do the job. Of course a dual sewerage system is necessary to carry out such a practice. In Los Angeles County such a condition will soon exist. Existing main sewers built from 20 to 25 years ago are reaching their designed capacities and relief lines are being built in many districts roughly paralleling the existing sewers. One of these lines can be made to serve all of the undesirable wastes, leaving a good portion of the sewage supply suitable for reclamation.

In the Los Angeles County Sanitation Districts sewerage system the main wastes requiring segregation are brines from oil field development and from the Metropolitan Water District softening plant at La Verne. The chloride content of the 100 m.g.d. of sewage at the joint disposal plant of the Los Angeles County Sanitation Districts would be reduced from 480 p.p.m. to 170 p.p.m. by the removal of 2 or 3 m.g.d. of Metropolitan Water District brine and 1 m.g.d. of brine from an oil refinery waste water disposal company.

Treatment of the selected raw supply is proposed to be accomplished in a suitable water reclamation plant and its associated spreading grounds. The function of the water reclamation plant is to produce an effluent that may be spread on percolation beds or spreading grounds at suitable rates without the development of odors. The function of the percolation beds or spreading grounds is to act as a slow sand filter to remove the organic materials, including bacteria remaining in the sewage effluent, and to deliver a potable water to the underground basin.

To make a suitable decision on the quantity and quality of effluents for spreading purposes, tests were run at a local trickling filter sewage treatment plant using the final plant effluent and a test spreading basin in a fine sandy material. The particular effluent and basin material were selected because they were similar to the conditions known and proposed to be present at the proposed projects. Bacteriological, dissolved oxygen, and B.O.D. samples of the influent and effluent at 4-, 5-, 6-, and 7-ft. depths showed absence of pollution (zero coliform index) and the existence of aerobic conditions at all depths throughout a 14-day test run. An average percolation rate of 1.0 acre-ft. per acre per day was indicated for this period. The suggested procedure for operation of actual spreading basins is a 2-week interval, during which time the basins would be filled, kept filled, dewatered, dried, and cultivated. Spreading time would approximate 7 days of this period. It was considered during the study that primary effluents might be spread, using proper rates, without causing pollution of underground waters. However, the almost certain existence of odors associated with this practice was considered sufficient to justify no further consideration of such a procedure. The Board concluded that nothing short of an oxidized secondary effluent should be applied to such spreading areas.

The opinions of several members of the California Department of Public Health were instrumental in setting up the test procedures described above, and although the data collected so far

are limited, they nevertheless were sufficient to map the course of the study recommendations. Other percolation tests are in progress at other locations, to determine more closely the limits of such spreading possibilities.

### Conditions Necessary

Of course, to get benefit from the outlined reclamation procedure the proper conditions must exist. Suitable natural spreading areas must be present in locations of free recharge; that is, in locations where spread waters will reach the underground aquifers. Such locations are not abundant and may or may not be efficiently located with respect to the available raw sewage supply.

In Los Angeles County the County Flood Control District operates many large flood-water spreading grounds, several of which are well situated to be supplied with reclaimed waters. The study fully considered the use of these facilities for reclamation purposes wherever possible. In certain areas of critical water needs where such spreading facilities are not available, suitable areas were located which could be developed into spreading grounds.

The possible use of existing local sewage disposal plants for water reclamation was fully investigated in the report. As most of these local plants become overloaded they will probably be inactivated in favor of participation in the County Sanitation Districts sys-

FIGURE 3.—Location of water reclamation projects studied in Los Angeles County, Calif.

| | |
|---|---|
| Capital Costs: | |
| Water reclamation plant | $1,434,000 |
| Spreading grounds (cost of existing grounds charged to flood control) | —— |
| Operating Costs: | |
| Water reclamation plant | $ 26.00 per m.g. |
| | 8.50 per acre-ft. |
| Spreading grounds | 2.00 per acre-ft. |
| 50-yr. average cost, assuming 4 per cent interest and operation 95 per cent of the time | $ 16.40 per acre-ft. |

tem. They then can be put to beneficial reclamation use. Plant processes would be simplified by the elimination of sludge digestion and digested sludge handling, and operation of several plants could be carried out by a single operating force. Storage could be provided in the smallest plants to collect a day's flow for inspection once daily before final delivery to the spreading areas.

## Cost of Typical Plants

The report presents detailed cost data for several proposed water reclamation installations. Condensed cost data for two of these projects are included here to indicate the general level of reclamation cost. Project locations are shown in Figure 3.

### *Whittier Narrows Project*

The Whittier Narrows Project would provide for the reclamation of 10 m.g.d. of sewage from the San Gabriel Valley area in the vicinity of the Whittier Narrows. A pretreatment works of the activated sludge type is proposed, with final effluent to be piped to the nearby Rio Hondo spreading grounds of the County Flood Control District for final delivery to the underground water basin.

### *West Basin Project*

The West basin project would include reclamation facilities of the activated sludge type for 10 m.g.d. capacity adjacent to the County Sanitation Districts joint disposal plant. Suitable primary effluent from the Sanitation Districts plant would serve as the raw supply for the reclamation works, with final effluent pumped to a suitable spreading ground to be developed in the West Basin area. Power for aeration and effluent pumping is to be generated from excess sludge gas of the Sanitation Districts plant not needed for the operation of that plant.

Analysis of the cost of imported water supplies to Los Angeles County indicates that the costs noted above are well within the range of feasibility. For example, as previously stated, softened Colorado River water delivered to member consumers of the Metropolitan Water District costs these consumers from $30.00 to $40.00 per acre-foot. A contract for a limited supply of surplus unsoftened Colorado

| | |
|---|---|
| Capital Costs: | |
| Water reclamation plant | $1,224,000 |
| Effluent pumping works | 518,000 |
| Spreading grounds | 258,000 |
| Total | $2,000,000 |
| Operation Costs: | |
| Water reclamation plant | $19.00 per m.g. |
| Effluent pumping | 2.50 per m.g. |
| Spreading grounds | 9.00 per m.g. |
| Total | $30.50 per m.g. |
| 50-yr. average cost, assuming 4 per cent interest and operation 95 per cent of the time | $18.00 per acre-ft. |

River water has recently been offered to Orange County by the Metropolitan Water District for $15.00 per acre-foot delivered to the Santa Ana River.

## Legal Aspects

The investigation revealed that there is no organization in Los Angeles County with clear-cut authority to develop and manage the reclamation projects outlined above. The County of Los Angeles appears to have such authority under provisions of the Government Code. However, the Board of Engineers concluded that the County Flood Control District would best be able to handle the organization and financing of suitable projects by revision of the Flood Control Enabling Act to permit subdivision of a flood control district into zones adapted to water reclamation. The Flood Control District forces would also be responsible for spreading reclaimed waters. The Board also concluded that the Sanitation Districts Enabling Act should be amended to permit the County Sanitation Districts to build and operate the sewage treatment works needed to produce reclaimed water, and to deliver the reclaimed water to the Flood Control District for spreading.

## Conclusion

This discussion has been limited to the use of reclaimed waters for augmenting underground water resources. The reclamation report includes, also, a discussion of beneficial use for industrial and agricultural purposes, which of course would indirectly aid in building up ground-water reserves by curtailing existing draft on the underground basins. There are some excellent opportunities for industrial use in Los Angeles County and such projects are under current study.

The direct recharge of underground basins through the use of natural sand filters seems especially significant for the following reasons:

1. The sand filters themselves not only serve as the means of recharge but also act as a final excellent check on water quality.

2. The vast underground water storage basins are most advantageously used in a storage capacity; thus they allow intermittent operation of reclamation plants and at the same time maintain a firm water supply.

3. Finally, water so returned to the underground can be used for any beneficial purpose, including domestic consumption.

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## LITERATURE REVIEW IN MAY ISSUE

Beginning with this year, the "Critical Review of the Literature" for the preceding year, usually an annual feature of the March issue of the Journal, will appear in the May issue. This rescheduling is necessitated by reason of the expanding periodical literature of the sewage and industrial wastes treatment fields, as well as by the time element involved in preparation of the copy with the Journal's monthly publication schedule.

# MAINTENANCE AND OPERATION OF METROPOLITAN BOSTON SEWERS *

By Thomas A. Berrigan

*Director and Chief Engineer, Sewer Division, Metropolitan District Commission Boston, Mass.*

The interception of domestic and industrial wastes from 31 cities and towns, including and surrounding Boston, Mass., and the disposal, without treatment, of these wastes at the present time into Boston Harbor is accomplished by three sewerage systems —namely, the North Metropolitan Sewerage, Boston Main Drainage, and South Metropolitan Sewerage systems. This paper deals with the North and South Metropolitan systems. The Boston Main Drainage works have been described elsewhere (1), as have also the proposed treatment facilities for both the Boston Main Drainage (2) and South Metropolitan systems (3).

## Description

The North Metropolitan system serves an area of 151.57 sq. mi., with an estimated population of about 700,000 contributing an average dry weather flow of 74 m.g.d. The system is comprised of 87.69 mi. of vitrified clay pipe, cement pipe, brick, and reinforced concrete sewers, varying in size from 15 in. to 11 ft. 3 in. in diameter. A total of 1,133.76 mi. of local sewers discharge by gravity into the system through 1,204 connections. The system is low level, with lifting operations at Alewife Brook, Charlestown, East Boston, and Deer Island. Except for the Alewife Brook section, the North Metropolitan system has capacity to handle the dry weather flow. It is, however, completely inadequate for handling the wet weather flow because large areas are served with combined sewers, with the result that mixed storm water and sewage escape through local and metropolitan overflows into the inland waterways during rainfall. The capacity of the presently constructed system at its terminus is estimated to be 125 m.g.d. and the outfall consists of 84-in. cast-iron pipe, which is tapered and provided with multiple outlets in the last 132 ft. and which discharges continuously at an elevation approximately 45 ft. below mean low water. It is estimated that the terminus capacity will be at least 425 m.g.d. when the North Metropolitan Relief Sewer is extended from Chelsea Creek to Deer Island.

The South Metropolitan system serves an area of 202.37 sq. mi., with an estimated population of 612,000 contributing an average dry weather flow of 70 m.g.d. The sewers in the South system are constructed for the most part of brick, with vitrified clay being used in outlying areas for the smaller sizes. Diameters vary from 15 in. at the outlying sections to approximately 12 ft. in diameter at the terminus at Nut Island, where a capacity of 272 m.g.d. is apparent. Outfalls consist of two 60-in. cast-iron pipes, turned vertically upward at the end and capped by a mushroom device, which continuously disperses the sewage horizontally at an elevation ap-

* Presented at 22nd Annual Meeting, Federation of Sewage Works Associations; Boston, Mass.; Oct. 17–20, 1949.

proximately 30 ft. below mean low water. The South system receives discharge from 251 local connections and is comprised of low- and high-level sewers, with major pumping operations in the high-level section at Ward Street in Boston and the Merrymount and Houghs Neck sections of Quincy. There are 68.65 mi. of South Metropolitan sewers and it is estimated that 1,158.76 mi. of local sewers, many of which are of the combined type, are connected.

The pumping station at East Boston is typical of the older pumping stations on the North Metropolitan system. Energy is supplied by 6 vertical hand-fired fire-tube boilers, with total capacity of 600 h.p. Four submerged centrifugal pumps with impeller wheels 8.25 ft. in diameter are driven by triple-expansion steam engines of the Collis type, with rated capacity for one unit at 100 m.g.d. at 19-ft. lift, and three units each at 45 m.g.d. at 19-ft. lift.

The largest pumping station in the South system is the Ward Street pumping station, where there are two vertical triple-expansion steam engines of the Allis-Chalmers type driving reciprocating displacement plungers, each 48 in. in diameter and of 60-in. stroke, and one 500-h.p. uniflow engine directly connected to a centrifugal pump. Each unit has a capacity of 50 m.g.d. with 45-ft. lift. Steam is furnished by 6 vertical hand-fired fire-tube boilers with a total rated capacity of 636 h.p.

The Braintree-Weymouth pumping station in the South system is a more recent installation. Here there are two pumping units consisting of De Laval centrifugal pumps actuated by 150-h.p., directly connected, diesel engines, each with a capacity of 15 m.g.d. at 30-ft. lift.

In addition to the steam and diesel pumping stations, there are float controlled and manually operated electric stations on both the North and South systems.

## General Organization

At present the Sewerage Division is staffed with 257 persons allocated as follows:

| | |
|---|---|
| Engineering and administration | 26 |
| Sewer lines maintenance | 50 |
| Pumping station maintenance and operation | 181 |

Appointment to the service is made by the Metropolitan District Commission, subject, however, to a determination by the Commission on Administration and Finance as to need for the position, and subject also to the Commission of Civil Service and Registration to a determination as to competence. This tri-commission arrangement affecting positions in the public service appears desirable, as it substantially reduces political selection and introduces a competitive motive in original appointment and promotion.

## Administration and Engineering

The present engineering staff consists of 1 chief engineer, 1 associate civil engineer, 2 senior civil engineers, 4 assistant civil engineers, 1 assistant sanitary engineer, 7 senior civil engineering aids, 1 inspector, 1 draftsman, and 1 junior civil engineering aid. Obviously, the engineering organization is not well balanced. Too much emphasis has been placed on civil engineering and insufficient emphasis on sanitary and mechanical engineering. This is the result of a previous policy, the aim of which was the expansion of a civil service organization during a construction program, but which thereafter failed to contract properly. To improve this condition it has been recommended that engineering beyond the capacity of the present force be accomplished by contract with outside consulting engineers, that emphasis be placed on the sanitary and mechanical aspects of civil engineering in civil service examinations, and that transfers be effected to other divisions of the

Commission where civil engineering services are urgently needed.

The engineering staff prepares plans, specifications, and contract documents for new construction, repairs, and replacements. Projects beyond its capacity are accomplished by contract with outside consulting engineers. The engineering staff also prepares all reports, maintains up-to-date records covering not only Metropolitan sewers, but also the local sewerage facilities of each of the 31 municipalities in the Metropolitan Sewerage District. It is further the duty of certain assigned members of the engineering staff to review drawings of all proposed local sewerage systems and to investigate and report on all establishments contemplating the use of inflammables, to insure that such materials are excluded from Metropolitan sewers. To facilitate this the Sewerage Division furnishes postcards, which are completed and returned to the Division headquarters by local licensing boards at the time of issuance of licenses to keep and maintain inflammables. Personnel assigned to this detail are equipped with combustible gas indicators. They conduct gas surveys and work in close cooperation with the Department of Public Safety. Further, where explosive mixtures in sewers are discovered, uninterrupted investigation is conducted to discover the offending party and immediate action is required to abate the condition.

All clerical work in the division is centralized in the main office and accomplished by a force comprised of 2 principal clerks, 2 senior clerks and 4 junior clerks. The work is divided into three categories; namely, personnel, materials, and general correspondence. The clerical force appears to be surcharged beyond its capacity to seasonably prepare all payrolls, material requisitions, budgets, long range programs, specifications, personnel records, legislative reports, and general correspondence of a division that annually spends $655,000 for personal services, $456,000 for materials and $337,000 for major replacements.

## Pumping

The organization charged with maintenance and operation of pumping stations numbers 181 and is composed of a superintendent and assistant superintendent of pumping stations; and a chief power plant engineer at each major pumping station, together with a complement of operating engineers, oilers, firemen, and laborers as appears consistent with the horse-power rating of the station. Until recently it was the practice to operate each pumping station with 4 shifts, with the day shift carrying additional personnel to handle repairs and replacements. This arrangement was satisfactory while the 44-hr. law was in force and sufficient personnel was available to cover vacation and sick leave periods without excessive amounts of premium wage payments for overtime. Due to the passage of the 40-hr. week law, however, more than a 10 per cent increase in operating cost has accrued, as it appears that additional personnel are not readily available to complete the complement of a "tramp" shift composed of steam power plant engineers, electric station operators, oilers, firemen, and laborers, who are not permanently assigned to a particular station but travel between pumping stations in the district as substitutes.

All the large pumping stations (East Boston, Deer Island, Ward Street, Charlestown, and Quincy) are more than 45 years old. Pumping equipment has not been replaced since the original installation, with the result that repairs and replacements are increasing in amount. Furthermore, replacement parts on most of the engines are not now available from the manufacturers and it has become necessary to make and stock special patterns at the carpenter shop at East Boston. Castings from these patterns are ob-

tained locally and most of the necessary machining is accomplished at the division machine shop by power plant engineers.

Most of the pumps at the stations are secured against damage by coarse bar screens, manually controlled. The screenings are burned in the power plant boilers. Burning in this manner has a deleterious effect on the boiler and seriously hampers steam generation. The manually operated coarse bar screens are particularly objectionable at the Ward Street pumping station because operators have failed on occasion to operate properly, with the result that screenings have become lodged in the poppet valves of positive displacement pumps and have seriously interfered with pumping efficiency. To improve the condition, it has been recommended that cage screens be replaced with mechanically operated screens and that shredders be provided to return the screenings to the sewage flow.

Occasionally, channel guides affixed to concrete to facilitate the raising or lowering of cage bar screens become corroded and require replacement without extended interruptions in pumping service. This work has been accomplished by discontinuing pumping operations for 1 hr. at a time and permitting the sewer line to flood. During this period divers are employed to descend into the sewers and effect installation of new channel guides, including the drilling and installation of expansion bolts, if necessary.

During World War II it was necessary to postpone the replacement of old pumping units because of the shortage of men and materials. Directly thereafter, there was an increase in the cost of replacements which exceeded the appropriation furnished by the Legislature, with the result that further postponement became necessary. At this time it appears that market conditions have sufficiently stabilized and contracts covering replacement of major pumping units at East Boston and Deer Island are under way. While this work is being accomplished by outside contractors the regular pumping station forces of the division are salvaging and stocking parts of old pumping units, which are not now available in the open market and which are urgently needed as replacement parts on other units.

Maintenance of all pumping units during the war and postwar period has been accomplished only with great difficulty, and then only when resort has been had to practices not recommended under normal conditions. For example, at one of the principal units at Deer Island, the pump casing was so deteriorated that it could be punctured by an ordinary pen knife. At the same time other units at the station were being quite regularly shut down for minor repairs. Under these circumstances, the sewer line maintenance force was directed to place mass concrete between the pump pit wall and the casing. By this means the operating period of the pump was sufficiently extended to enable the station to function until a new pumping unit was provided.

### Sewer Line Maintenance

About 33 personnel are devoted to maintenance of sewer lines on the North system and 17 on the South system, with principal yard headquarters at East Boston and Ward Street, respectively. Subsidiary yards are available on the North system at Winchester and Alewife Brook and on the South system at Houghs Neck. A superintendent directs the activities in each system where groups, headed up by a foreman or carpenter, are arranged, depending on whether the work is a sewer line job or the direction of activities in the carpenter shop. Classifications such as laborer and chauffeur predominate, and a limited number of mechanics, such as bricklayers, pipe fitters, and roofers are apparent.

Sewer line maintenance personnel clean sewer lines, remove grease and other organic accumulations from head houses, etc., maintain Metropolitan tide gates in operating condition, inspect tide gates at local systems after each rainfall, handle coal, remove ashes, patrol lines, keep growth in the vicinity of manholes and head houses cut, paint and make minor repairs to buildings, raise manholes to satisfy grade changes, maintain grounds, remove snow, assist on major pumping repairs, respond to all complaints attributable to flooding and odors, locate manhole covers, inspect new connections, adjust and repair regulators, and remove sediment from pump wells.

To accomplish sewer line maintenance work several essential types of equipment, in addition to a miscellany of small tools and special devices for cleaning sewers, are available as follows: trucks, beach wagons, pumps, compressors, blowers (hand and machine), sewer cleaning machine, $H_2S$ detectors, CO tester, safety lamps, combustible gas detector, life belts, air masks, and sewer cleaning tools.

Sewer line maintenance problems in Metropolitan sewers do not require attention to catch basin cleaning, blockages, odors, cleaning, and flushing to the extent experienced in local systems. To begin with, there are no catch basins, and the sewer lines are for the most part well-constructed gravity lines with ample ventilation and with velocities ranging around 3 ft. per second, except in the Aberjona Valley where industrial wastes substantially increase the viscosity of the sewage and reduce the velocity by one-third. Occasional complaints due to hydrogen sulfide are received where the North Metropolitan system passes through a residential section near Craddock Dam. This condition is attributable to the fact that the relief sewer has not been extended to the outfall, goes into action only in times of storm, and cannot be completely dewatered with the present pumping facilities. As a result, mixed sewage and storm water is retained between rainfall periods, stagnation results, and hydrogen sulfide is generated. To minimize this odor nuisance a ventilating flue has been extended up the trunk of a tree from a crossover head house on the relief sewer. In addition, calcium hypochlorite is generously sprinkled in head house chambers of all siphons on the line for the purpose of oxidizing the sulfur and arresting biological processes.

Cleaning operations are necessary in the pump wells of float control stations and in Metropolitan lines established in the Aberjona section, where industries such as tanneries, gelatin, and glue works neglect to adequately remove settleable solids from the wastes. About 10 years ago, when the relief sewer was being constructed, at a location just below an industrial development and adjacent to an existing Metropolitan sewer, a long so-called diversion chamber (much like a grit chamber) was constructed to intercept much of the heavier settleable solids and to facilitate easy removal through concrete planks in the roof of the structure. Nevertheless, this precautionary measure has not proved adequate, and substantial amounts of cleaning are required in this area. This work is accomplished with power bucket machines, contrivances comprised of structural steel frames mounted on portable chassis and equipped with gasoline engines, cables, drums, and pulleys, which are set over adjacent manholes and further arranged so that a collapsible steel bucket may be conveniently moved backward and forward in the sewer line to facilitate the removal of solids. To facilitate placement of the cable necessary for the operation of the apparatus a flexible cable is introduced through a smoothly bent pipe, which leads from the ground through the manhole to the sewer line. This arrangement makes it possible to get the machine cable through the

sewer line without requiring workmen to assemble wooden sewer rods under difficult conditions at the base of the manhole. It is, however, necessary to descend into the manhole to install the idler that changes the cable direction from horizontal in the sewer line to vertical in the manhole.

### Sewer Use Regulations

In 1947 the Commission obtained legislation covering character of discharge into Metropolitan sewers. In pursuance thereof, rules and regulations have been promulgated prohibiting discharge into any sewer under the control of the Metropolitan District Commission, or any sewer tributary thereto within the North or South Metropolitan Sewerage District, in volumes determined by the Commission to be excessive, of any sewage, drainage, substances, or wastes containing:

1. Caustic alkalinity, calculated as $CaCO_3$, in excess of 75 p.p.m.
2. Unsaponified greasy or fatty matters.
3. Suspended solids in excess of 500 p.p.m., or any matters in such volumes as may tend to obstruct or impede the flow in the sewers, or be injurious to the sewers, pumps, or other portions of the sewerage systems, or be likely to create a nuisance or a hazard within or without said sewers.
4. Free mineral acids in quantities determined to be excessive.
5. Industrial or manufacturing effluents, unless means of measuring the flow are provided and the records made available to the Commission.
6. Explosives or inflammables.
7. Ground, tide, or river water.

The rules and regulations further stipulate that:

8. All applications to discharge any industrial sewage, drainage, substances or wastes directly into any sewer under the control of the Commission shall be accompanied by an agreement signed jointly by the owner of the industry contributing such sewage, drainage, substances or wastes and a representative of the municipality in which the connection is located who is authorized to sign agreements on behalf of the said municipality stating that the manufacturer or industry in question agrees to abide by all rules and regulations of the municipality and the Metropolitan District Commission and that the owner of the industry will provide suitable devices or other means for measuring the flow of the sewage, drainage, substances or wastes and will provide such works for the preliminary treatment of the sewage, drainage, substances or wastes as may be required by the Metropolitan District Commission.

9. Municipalities will be held responsible for the enforcement of that section of the rules and regulations of the Massachusetts Department of Public Safety necessitating that garages and other establishments where gasoline is used and which are connected with the public sewers in the North or South Metropolitan Sewerage Districts be supplied with a suitable trap or separator subject to the approval of the Metropolitan District Commission.

10. No municipality shall contract for the building of additional sewerage works contemplated for connection into the Metropolitan Sewerage System until plans and specifications covering such works are submitted to and approved by the Chief Sewerage Engineer of the Metropolitan District Commission, and notice is hereby given that the Metropolitan District Commission will not approve, except under extraordinary conditions, any works designed on the so-called combined system or the discharge of processing or condensing water which the Department of Public Health determines is sufficiently free from contamination to permit its discharge into the nearest water course.

### Salt Water Infiltration

It is thought that tide gate inspection and maintenance has not been adequately covered because of the excessive amount of chlorides entering the system through tide gates located in harbor estuaries, or through local manholes or adjacent sewer lines. Obviously, excessive concern about pumping efficiency is unwarranted when it is apparent that during dry weather flow chemical analysis of the sewage shows a chloride content, measured as sodium chloride, in amounts up to 10,000 p.p.m. To rectify this condition sampling stations have been established for the purpose of recording profiles of chloride concentrations and thus determining by chemical rather than mechanical means whether in fact tide gates are properly functioning.

### Accidents

Persons engaged in the business of maintaining and operating sewerage systems should be ever alert to secure against serious accidents. For that reason four incidents in connection with Metropolitan sewers are reported herein, for the purpose of emphasizing the importance of security measures.

In the first case, about 35 years ago, a workman descended the screen chamber of the East Boston pumping station with an electric bulb on the end of an extension cord. During the descent the bulb struck the side of the chamber and broke. Directly an explosion occurred which blew the roof off the station, killing six men and injuring two others. The best explanation of this accident appears to be that the sewer was full of gasoline vapors that ignited when the electric light lamp broke.

The moral to be gained from this unfortunate accident is that inflammable materials should be excluded from sewers and, further, that sewer chambers should not be entered without testing for combustible gases, hydrogen sulfide, and oxygen deficiency, and then only after adequate ventilation and when equipped with life belts. Further, where ventilation cannot be adequately supplied, gas masks and separate air supply should be used.

In the second incident, three laborers entered a regulator manhole on the Metropolitan sewer in Chelsea about 12 years ago for the purpose of repairing the regulator. The three men were located vertically on the manhole steps directly above the chamber. The lowest man fell into the sewer, the middle man became dizzy while climbing out, and the uppermost man in the chamber tumbled over the middle man into the sewer. The body of one man was picked up on a cage screen at Deer Island later the same day. The other man's body was found 4 weeks later floating in a remote section of the East Boston pumping station suction chamber. This accident, attributable to a deficiency of oxygen or a high concentration of hydrogen sulfide in the regulator manhole, could have been avoided by testing for gases before entering, or by the use of life belts.

In the third case, a small boy, accompanied by his playmates, was exploring a remote area in Dorchester and disappeared from sight through an open manhole of a Boston sewer which fed into the South Metropolitan system. Late that evening the boy's body was removed from the cage bar screen at Nut Island. So far as could be determined, a manhole cover had been removed by pranksters. Although it is impossible to secure absolutely against this, regular patrols of sewer lines through uninhabited areas is important to minimize the occurrence.

The last incident involved a City of Chelsea water service worker, who, while excavating to repair a water line, disappeared from sight through a void which developed at the base of a water pipe trench. Several weeks later the body of this man was extracted from

a mass of street paving blocks a short distance horizontally from a Metropolitan sewer and at an elevation 35 ft. below the street surface. Investigation disclosed that the sewer was cracked and had been constructed in very fine sand. It is difficult to speculate on why the crack occurred in the first place; that is, whether it was due to loss of ground during tunnelling operations, deterioration of the sewer, a pressure induced by surcharged conditions at the inside of the brick arch sewer, or a combination of these. At any rate, the crack came into being; fine sand infiltrated over a period of years, resulting in a void which was not apparent at the surface because the 12-in. thick concrete pavement was structurally sufficient to arch to a considerable extent. However, when this pavement was broken and excavation proceeded to facilitate water pipe repairs, an elevation was reached where there was no support at the base of the trench.

Unfortunately, this sewer is the main Metropolitan sewer and cannot be repaired from inside except at great expense, and then only by diverting practically all of the North Metropolitan sewage into the adjacent river. As a temporary expedient, ground on the outside of this sewer has been stabilized with grout and it is proposed to repave the whole area with a flexible pavement, having in mind that it is better to experience surface settlement and refill than to permit a hazardous condition to exist. In the opinion of the writer most 50-yr. old brick sewers are in need of repair or replacement. In the present case the suggestion has been made that the sewer be relined with centrifugally-spun concrete pipe of slightly smaller diameter, with the space between the inside of the old sewer and the outside of the concrete pipe dry-packed with stiff cement mortar.

## Conclusion

Maintenance and operation of sewerage systems and the organizational setup in connection therewith have been overshadowed in the literature by other aspects of the profession. However, maintenance and operation of sewerage systems are worthy of greater attention and it is hoped that more engineers particularly qualified in the sanitary engineering field will become interested in investigations and report their activities and findings in technical papers.

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## DISCUSSION

By William P. Gyatt

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It is evident from Mr. Berrigan's fine paper that the sewer operating problems of Boston, although on a larger scale than most of us encounter, are not materially different, with some variations, from similar problems in many other communities having sewer systems of reasonable size.

The various problems of sewer operation and maintenance are the results of many conditions and factors. Some of the problems result from conditions created long before many of these sewers were even contemplated. Mother nature started by creating contours and subsoil structures that often make

it impossible or difficult to build sewers in desirable locations at desirable grades. The result is often compromise, too often to the disadvantage of the future maintenance work. Frequently, due to lack of good sewer engineering, short cuts in construction methods, or compromises due to financial reasons, the maintenance organization winds up with a continuous headache in its efforts to keep these sewers operating efficiently.

Most superintendents could do a fairly good job of sewer maintenance, even with many of these inherited difficulties plus the normal sewer problems, if only the city fathers could be induced to provide the funds needed to employ the required equipment, labor, and materials to permit making the necessary adjustments and corrective construction. However, most sewers are built below grade so are unseen, as a result of which few local citizens are much concerned about sewers. The funds for sewer construction and sewer maintenance are usually provided only when conditions will no longer permit side-stepping the issue.

The operation and maintenance of the two systems described by Mr. Berrigan is affected in varying degrees by the previously mentioned influences, more particularly by the need for funds to provide the proper corrective measures. This appears evident from the fact that all the large pumping stations are more than 45 years old and the original equipment is still being used, in spite of the fact that repairs are frequent and costly, and that replacement parts are no longer available and have to be custom made in the Sewer Divisions own shops.

The improvements in the design of pumps and pumping equipment in the last quarter century, with corresponding increases in pump efficiencies, would very probably, in recent years, have saved enough in operating costs and repairs to have paid for the installation of more modern equipment. Steam may have been used in the original installation to provide for continuity of service, because electric service was rather uncertain 45 years ago. This is no longer true, and even if electric service for these larger stations is still undesired there are the much more efficient steam turbines or the more modern diesel engines, either of which, together with more modern pumps, would probably save their capital costs plus the saving in costs of labor and materials required to make the frequent repairs necessary to the present equipment.

In his description of the operating organization, Mr. Berrigan states that the competence of applicants for positions and promotions in his organization is subject to civil service determination. This is certainly a desirable process and should be more universally used for all similar organizations, with a corresponding improvement in personnel. It is noted that the engineering organization is not as well balanced as desired and that the over-emphasis on civil engineers should be adjusted so that the mechanical and sanitary engineering phases of the organization could be supervised by engineers trained in these particular endeavors. This is certainly a proper and logical corrective measure and should result in a more balanced engineering unit.

From the description of material and equipment used for sewer line maintenance work it appears that the Commission has a well equipped organization, both for sewer cleaning and, more important, for the safety of the employees engaged in these cleaning activities.

The almost universal difficulties with industrial wastes, particularly in larger sewer systems, has not by-passed Boston. The 10 regulations of the Commission appear to cover about all possible types of wastes harmful to sewer structures, or which might create dangerous hazards in the sewer systems.

It is probable that most communities having industrial waste discharges into their sewers have some type of similar regulations, although perhaps not as specific or complete. In Syracuse, similar regulations have been incorporated in the plumbing code and the original installations are carefully checked by plumbing inspectors or, if necessary, by other city agencies to be certain of proper compliance with the code provisions.

These protective regulations are proper and must be complied with, but unfortunately they are of little effect unless a constant check is made to see that changes in the manufacturing establishment or in the processes involved are properly provided for after the original connections have been approved.

In Syracuse, it is required that all garages or other establishments discharging waste oils shall have proper and approved oil and grease traps and that this equipment be installed by the owners. On frequent occasions, however, usually during the night or at weekends, it is found that someone has let a load of oil get into the sewers, with the result that the settling tanks at the treatment plant are more or less covered with a film of oil. It is almost impossible to trace this trouble to the source by an inspection of the sewers, although attempts have been made to do so.

A large dairy, located near the central part of the city, during the war began to discharge considerable quantities of broken bottles into one of the sewers discharging through an interceptor into the main intercepting system. The glass would load up the interceptor in a few days so that it would not operate. It was necessary for the crew in charge of the operation of these devices to clean this particular unit every week. Phone calls did not seem to get results, so I took the foreman of the cleaning crew and called on the manager of this plant. Of course, he maintained that it was not his plant that was discharging the glass—until we convinced him by showing him several pieces of broken bottles with the dairy name. This man was still not convinced that this was possible for when the plant was constructed considerable money had been spent in building concrete sumps for the specific purpose of trapping this broken glass. He then called in the plant superintendent to verify this fact and prove that we must be wrong. When the plant superintendent was asked how frequently these sumps were cleaned he did not know, and when asked to be shown these structures he and another employee spent about an hour trying to locate them. The sumps were there and they were of ample size so that normally they would have done a good job—but both units were so full of glass that it was difficult for the waste water to pass through the tanks and, of course, all the surplus glass passed along with the water into the sewer. Other instances of similar nature could be cited to show that all these various protective regulations and devices are of little or no help unless constant inspection is made to see that the protection is sufficient and functioning at all times.

Mr. Berrigan describes several accidents, some of which resulted in considerable property damage and loss of life. Human nature being what it is, there probably never will be a time when accidents will not develop. It is true, however, that careful supervision and thorough training of employees, together with proper protective equipment, should greatly reduce these losses. It is not likely that any sewer system of any size today is entirely free from gasoline fumes, regardless of every reasonable precaution on the part of persons responsible for these sewers.

A few years ago a crew was making an inspection of an inverted siphon that passed under a stream flowing

through the center of Syracuse. The siphon had become partly plugged and the crew had been instructed to correct the situation. The man in charge of the crew was an old-time, well qualified construction man and had worked on the construction of the system, during which time two engineers had died from gases in a deadend manhole. He knew that if a flame was put out by gases in a manhole it was a good plan to stay out, as there were probably dangerous gases present. In order to test the siphon manhole before sending any one down, he had the cover pulled, then very carefully lighted a newspaper and dropped it into the manhole. He proved that there were no deadly gases present, but he singed his mustache, eye brows, and hair on his hands from the back fire caused by the gasoline vapors present. Fortunately, no other damage was caused and you may be sure that neither this man nor any of his crew ever tested for gases by that method again.

The writer thoroughly agrees with Mr. Berrigan in his conclusions. Altogether too little effort is made by most communities to maintain their sewer lines and systems at peak operating condition. Too often the only time any one inspects the sewers is when there are complaints because of backing up in cellars, odors, or some other unusual condition. This situation is generally not so much because of neglect of these sewers by the responsible parties as it is that they do not have sufficient funds to carry an organization large enough to do this job the way it should be done.

Even when funds are available this work often is given to unskilled men because, at best, it is a dirty job. Proper sewer maintenance is an activity that should be as well provided for as street repairs or street cleaning, and should have supervision that understands the problems from an engineering as well as a practical viewpoint.

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# MECHANICAL EQUIPMENT IN SEWAGE TREATMENT *

By Frank L. Flood

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It is the intent in this paper to cover in part the author's experiences with sewage treatment plant equipment, dealing principally with well-known and tried equipment having broad coverage and large usage. New and relatively untried equipment will be only briefly touched upon. In any event, it is impractical in a paper such as this to cover all developments.

A discussion such as this must be colored by individual experiences, and any conclusions expressed must be weighed accordingly. The characteristics of sewage and of the materials removed from sewage vary so widely from time to time and from place to place that individual experience with any particular piece of equipment may range from highly satisfactory to unworkable.

It is the designing engineer's aim to procure equipment that will operate with economy, satisfaction, and long life. The manufacturers are also seeking the same results; but they are in a highly competitive field, and unless the plans and specifications are carefully drawn the client will not always obtain the best equipment available. It is hoped that this paper and any attendant discussion will be helpful toward accomplishing the desired goal.

Reference is made to such publications as "The Sewerage Manual" (1) for a comprehensive description of sewage treatment plant equipment.

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## Coarse Screens

Operation of mechanically cleaned bar racks has frequently been a source of difficulties and has resulted in costly maintenance. The problems at the Chicago Sanitary District, and their solution, have been described in detail by L. M. Johnson (2). The fundamental principles of design which greatly reduce the need for repairs and adjustments have been covered by Johnson, and are well worth reviewing by engineers confronted with the problem of designing and specifying mechanically cleaned racks.

The city of New York has settled on a design of rack in which the teeth enter the screen bars against the flow at the bottom, moving in an upward direction with the teeth protruding between the bars, carrying screenings along the bars and over the top, the screenings falling off the ends of the bars as the rakes disengage the screen bars. This design was adopted after satisfactory results had been obtained with equipment of this type at the Manhattan grit chamber. The racks for the Nut Island plant in Boston and the Ashbridges Bay plant in Toronto are to be of similar design.

Experience has demonstrated that wear and tear, maintenance, and operating costs are almost directly proportional to the hours of operation. It is desirable, therefore, to provide for intermittent operation of the rakes. The operation of controls by differential head on the rack appears to be a reasonable and practical method of obtain-

ing the desired results. The use of differential air pressure has proved satisfactory for this service.

*Screenings Grinders*

The automatic feeding of coarse screenings to grinders has sometimes caused difficulties. It appears desirable in some cases to discharge the screenings upon a sorting table, from which metallic and bulky materials can be removed prior to grinding. The screenings can then be fed to the grinder at rates within its effective capacity. For multiple racks in large installations, the location of a grinder at each rack provides ready means for control of grinding operations. The initial cost of the installation may be higher than as if the screenings were collected from several racks on a belt conveyor and fed to separate grinders, but the operations are under better control and in the long run have proved to be more satisfactory at some plants. At Baltimore, Md., there are a number of installations of mechanically cleaned racks in which the rakings at each rack discharge to a short belt conveyor. The rakings are thence carried to a separate grinder for each rack. These installations are reported to work satisfactorily without manual raking and removal of metallic and bulky materials.

*Comminution of Screenings*

Provision has been made at the Hyperion plant in Los Angeles, Calif., to discharge all the screenings from the racks to a channel taking a portion of the sewage flow to comminutors. Similarly, the screenings from the racks at Boston's Nut Island plant will be disposed of in sewage channels equipped with comminutors.

Until recently, the Chicago Pump Company's comminutors have had competition in this field primarily from a combination of mechanically cleaned rack and grinder or triturator. The Worthington comminutor has recently been introduced, and other machines for cutting up solids in the sewage flow have been or are being developed.

## Grit Chambers

Due to the abrasive character of the materials handled and other operating conditions, grit chamber equipment has been subjected to a high rate of wear and tear. The emphasis should be placed, therefore, on rugged, durable construction with ready means for replacement of worn parts. Renewable wearing shoes should be provided on the attachments which support the chains, flights, scrapers, buckets, stirrers, and other moving equipment in the grit channels. The rails subject to wear also should be readily replaceable. Chains should have hardened steel pins and be of extra-heavy construction.

Belt conveyors for transportation of grit from multiple grit channels to grit washing, storage, and disposal points, appear to operate with less maintenance costs than scraper or spiral conveyors.

The grit is removed from the grit channels at the District of Columbia Blue Plains plant, by means of inclined screw conveyors. This equipment was originally supplied with the thrust bearings near the bottom of the grit hoppers. Because of continual submergence in grit the bearings lasted only a very short time. To overcome this difficulty the bearings were replaced by ball-thrust bearings above the sewage level. In addition to eliminating the frequent failure of the underwater bearings, much smoother operation of these units resulted.

Maintenance and operating costs for grit collecting, removal, and washing equipment are affected both by the quantity and character of the grit handled and by the hours of operation. Continuous operation may be advisable during storm flows and intermittent operation during periods when grit accumulates at a low rate.

The velocity in grit chambers has been controlled by the installation of various devices including proportional weirs, Parshall flumes, and Camp regulators. In a considerable number of the newer plants the use of the Parshall flume for both control of water level in the grit channels and for measurement of sewage flow has proved practical and economical. Frequently, it has been found desirable to provide a rate-of-flow indicator at the flume and a remote recorder installed in the plant office or at other control points.

The need and extent of facilities required for "washing" grit for the removal of organic materials depends on the method available for its ultimate disposal. In some plants adequate results have been obtained by returning the grit as first removed during periods of intermittent operation, back to the inlet of the grit channels at the surface of the flow for a short period before finally removing it for disposal. The grit is thus washed in the sewage flow and after washing is removed for disposal.

Other plants are satisfied with the results obtained from reciprocating devices on inclined planes such as that used by the Dorr Company in connection with its Detritor. Inclined screw conveyors (such as are provided by the Link-Belt Company at Peoria, Ill., and the Chain Belt Company at the District of Columbia) afford a measure of washing action.

The Jeffrey Company, in its "Jigrit" washer, especially developed for scouring and hydraulic separation of organics from grit, utilizes the principle employed in cleansing and separation of ores.

The successful operation of mechanical equipment for removal, handling, and washing grit usually involves considerable care and expense for maintenance work.

An aerated grit chamber of spiral flow characteristics at Columbus, Ohio, has been described by Grant (3). Grit is collected in hoppers under the diffusers and removed by a clam bucket. Grit is removed from other smaller installations of this type by means of water-jet pumps. The possible advantages of this method of grit collection include the elimination of wear and tear on mechanisms collecting the grit, and production of a clean grit without special washing mechanisms. Precise control of velocity is not required and variations in rate of flow through the tank are of little importance. The possibilities of using this type of grit chamber in conjunction with pre-aeration tanks remain to be explored.

## Sedimentation Tanks

### *Rectangular*

Equipment for sludge collectors in rectangular tanks is in a highly competitive field. For fair competition and in order to obtain the best equipment available with assurance of satisfactory operation and long life, it is necessary to specify the equipment in considerable detail.

It has been found advisable to eliminate multiple sludge hoppers at the inlet ends of rectangular sedimentation tanks so far as practical. This has resulted in the use of cross-collectors in relatively narrow tanks. Chain and flight conveyors are normally used for this service. Spiral conveyors have proved to be adaptable in specific cases.

Recently, the use of "hunting tooth" or "extended life" sprockets has been given considerable publicity. In effect these are designed to double the number of teeth on the sprocket and to reduce the wear on each tooth by 50 per cent. It is believed desirable to specify sprockets of alloy cast iron with a nickel content of 1.00 to 1.25 per cent and a chromium content of 0.45 to 0.65 per cent. The sprockets should be chilled to give them a hardened tooth surface.

Because excessive chain wear may cause excessive sprocket wear, it is ad-

visable to obtain a rugged, durable chain. Hardened steel is recommended in place of soft copper-bearing riveted steel for pins, so as to cut down chain elongation to a minimum and thereby reduce chain and sprocket wear.

It is advisable to specify the size and unit weight of chain desired for any particular project. Otherwise the proposals from the various manufacturers may not be on a comparable basis.

Unless otherwise specified, chain attachments are commonly bolted to part depth of the flight. Some manufacturers recommend that these attachments be made to the full depth of the flight in order to strengthen the flight against splitting. There is some evidence that the full-depth attachment is advisable.

It also appears advisable to specify bolts of not less than ½-in. diameter and structural steel of not less than ¾-in. thickness for support of return flights.

The flights may be provided with readily removable wearing shoes inserted into holders bolted to the flights at points of contact with rails in the tank bottom and with supporting angles on the return flight.

Some of the manufacturers recommend use of adjustable overload release devices to mechanically disengage the collector from the motor when overloads are encountered, as a substitute for shear pins. The Chicago Sanitary District is well satisfied with the operation of individual motorized reducers on sludge collectors, wherein all parts except flights are designed to withstand the maximum torque of the motor. Consideration must be given to the motor size and to selecting characteristics such that the maximum torque is not materially greater than the running torque. Particular attention should be given to possible deflection of shafts and consequent effect on bearing mountings. Self-aligning bearings are helpful to prevent difficulties in this respect. The life of chains, sprockets, bearings, and wearing shoes for equipment installed in rectangular primary sedimentation tanks can be prolonged by operating the mechanisms only as required for a short time before and during sludge withdrawal operations.

Rotated slotted pipes provide a simple means for manual control of scum withdrawal. Where such manual control is too laborious it is possible to utilize mechanical means. One of the simple mechanical skimmers consists of a rotating spiral squeegee, which carries the skimmings up a launder and discharges them into a scum trough. This has been adopted for the Los Angeles Hyperion primary settling tanks.

At the Boston Nut Island plant provision is made for conveying the scum while still floating on the sewage to one scum storage sump for each of two large rectangular tanks.

Short suction lines between the sludge hoppers and raw sludge pumps are desirable.

*Circular*

At the Chicago Sanitary District it is reported that the equipment in the circular sedimentation tanks is specified to withstand the maximum torque of the motor. Shear pins are not permitted.

The operation of drive units on rails at the periphery of circular tanks has been troublesome in the northern states, because of slipping under icing conditions.

The equipment in circular tanks does not have as many moving parts as that in rectangular tanks, and the problems of maintenance as a rule are less difficult in the case of circular tanks. However, in some instances, due to electrolytic action or for other reasons, the equipment in circular tanks has corroded so seriously that the anticipated life of the equipment was not realized. A suitable schedule of inspection, painting, and other maintenance and repair work would in

most cases assure satisfactory life of the equipment.

In some large circular primary sedimentation tanks it has been found desirable, in order to withdraw reasonably well concentrated sludge, to provide automatic programmed intermittent operation of the raw sludge pumps.

In large circular final settling tanks, it has been found advantageous to install supplementary weir capacity in addition to that normally available at the periphery of the tanks. This may be accomplished by the installation of a trough within the tank and supported from the outside wall.

### Trickling Filter Distributors

There is thought to be little difference in performance between the distributors discharging with a rain-like spray and the conventional rotary distributor. However, the driving of rotary distributors by electric motors may add to the cost of operation, maintenance, and repair as compared to the conventional reaction-driven distributor. As the latter operates with a head of only a few feet at the most, the inclusion of motor drives may seldom be justified.

For distributor arms, it is believed advisable to specify genuine wrought iron. Supporting tie rods should be not less than ½ in. in diameter.

Four-arm distributors with two of the four arms equipped with weir boxes on siphonic overflows, provide for operation under a considerable range of flow between minimum and maximum.

### Aerators

The problems encountered in air diffusion have been serious enough to warrant the preparation of a Manual of Practice in connection therewith by a committee of the Federation. This will be ready for publication shortly and the subject is so thoroughly covered therein that there is no need to include a comprehensive discussion of air diffusion in this paper.

The problem of cleaning clogged air diffuser plates has led to the development of means for ready removal of the diffusers from the tanks. This is accomplished by the Chicago Pump Company through swing diffusers. This same company also stresses the efficacy of wide-band aeration and the flexibility inherent in the swing diffuser system, in that tubes can be added or removed from each swing diffuser unit as experience may prove advantageous. There also has been developed a new light-weight tube consisting of Saran plastic cord wound tightly and closely around a corrugated stainless-steel core. A large installation of 6,000 tubes at Columbus, Ohio, is reported to be very satisfactory, but final judgment on the tube must be postponed until more operating data are available.

Aluminum diffuser plate containers have failed in some notable instances.

### Chlorinators

The manufacture of chlorination equipment has, since World War II, become highly competitive. Engineers responsible for preparing specifications should become conversant with the various types and grades of feed machines. It is difficult under present conditions to evaluate the equipment of the various manufacturers. The situation will probably be clarified as the newer machines become better known and experience in their operation accumulates.

Substantial savings in cost of chlorine should be possible in the larger plants with automatic programmed control of chlorine feed as available in some recent models.

### Sludge Digestion Tanks

Possibly the single greatest difficulty experienced with the operation of sludge digestion tanks has been in ac-

cumulations of masses of relatively inert scum, which render ineffective a substantial proportion of the tank capacity, clog supernatant and overflow pipes, and create numerous operating problems. It appears that if the scum is kept well mixed with warm tank liquors, the scum-forming materials will continue to digest and for the most part settle to the bottom with the sludge. If well lubricated by tank liquors, excess accumulations of floating materials can be withdrawn through piping connections in the upper portion of the tank.

Several schemes have been developed to meet the scum problem. A few will be briefly described. In tanks equipped with floating covers the Pacific Flush Tank Company recommends the installation of a circulation system designed to produce a flow and mixing action at the center of the tank in the gas dome. In theory, scum accumulating under the floating cover and outside the limits of the gas dome will flow into the center and receive treatment.

The Dorr Company recommends installation of propellor mixers installed in the scum zone below the roofs of fixed-roof tanks to mix the scum with the underlying tank liquor. Where particular types of industrial wastes are to be encountered this company has recommended mechanical mixers with slowly revolving stirring arms passing between fixed teeth suspended from the roof.

For fixed-roof tanks the author has recommended the circulation of liquor at relatively high rates, the liquor being drawn from beneath the scum zone and discharged just above the normal liquid or scum level. Four discharge nozzles are located at about quarter points in plan and inclined at about 45°, directed so as to cause a circulatory motion in the scum and to bring scum not directly under the nozzles into the active turbulent mixing areas (4).

Although many installations of fixed heating coils placed within digestion tanks have given satisfactory results over long periods of time, some installations have proved troublesome. Difficulties have been ascribed to a number of causes including inadequate area of heating surface, crusting of sludge on the pipes to a degree that their heat-transference capacity has been so reduced that it has become impossible to meet the heating requirements, and structural failures with collapse of piping supports and piping. It is probable, in some instances at least, that difficulties with inadequate area of heating surface have led to crusting on the coils.

Because of the difficulties mentioned, engineers and manufacturers have developed a variety of means to eliminate the heating coils. External heat exchangers have been advanced by several manufacturers. Direct contact combustion heaters have been installed in the digestion tanks at the Philadelphia Northeast treatment works and at Baltimore. The digestion tanks at the Hyperion plant in Los Angeles are equipped with mixers in which provision is made for admission of steam for heating purposes into the flow tube below the impeller.

Infilco has developed a so-called "Vorti-Flow" impeller for installation in the scum zone at the center of the digestion tank. Heating coils are installed in a vertical bank which can be withdrawn through a manhole in the roof.

By and large the equipment installed within digestion tanks prior to World War II has not proved very satisfactory. It is hoped that the newer developments will show longer life and better results. Operators are understandably not very happy about cleaning out a digestion tank to make repairs on mechanical equipment installed therein.

### Vacuum Filters

Considerable trouble and expense have been caused by corrosion of vacuum filter equipment dewatering ferric chloride conditioned sludge. Where vacuum filters operate only a few hours per day the corrosion does not show up for some years. However, in larger plants requiring practically continuous operation, corrosion in the filters of conventional construction occasionally becomes troublesome within a few months. It appears advisable to specify Everdur bronze screens, staples, division strips, etc., for filters to be used for such service. The pipe and fittings between the drum compartments and the trunnion conduits should also offer more resistance to corrosion than is possible with copper and bronze construction. The most practical and economical system of pipe and fittings may still be open to development. However, it would appear that plastic materials such as Saran or Uscolite are suitable.

Recent developments in the cord- and spring-wound filters are promising.

One of the newer vacuum filters has all vacuum piping connections outside the filter drum, thus greatly facilitating their repair or renewal.

Experiences in the operation of vacuum filters dewatering sludge conditioned with lime have been described in the annual reports of the Minneapolis-St. Paul Sanitary District. Continuous washing of the filter cloth is reported to be helpful in increasing the length of filter runs.

At the Hartford, Conn., and Cranston, R. I., sewage treatment plants the vacuum filter companies have supplied distributors for filter cake on conveyors which rotate against the movement of the cake. These proved unsatisfactory in that they piled up the cake to such an extent that jams resulted. Distributors rotating with the movement of the cake proved very satisfactory. The blades or wheels should be made of a hard alloy resistant to wear from abrasion.

### Sludge Driers and Incinerators

The design of various types of sludge drying and incineration equipment and appurtenances is subject to continuing development and refinement.

Nichols-Herreschof multiple-hearth driers and incinerators have been selected for the Toronto Ashbridges Bay plant on the basis of competitive bidding with flash driers. When running as driers, the burners will operate in the upper hearths, which have been given added combustion space, and the hot gases will be drawn downward through the hearths for bottom take-off. When running as incinerators, the burners will operate in the lower hearths and the hot gases will rise in the conventional manner through the upper hearths.

The operation of a multiple-hearth incinerator at Ashland, Ohio, on incineration of liquid sludge, has been described by Laboon (5).

For both multiple-hearth and flash-drier types of equipment, careful attention must be given to design and selection of materials that will give reasonable life under the particular temperature and service conditions to be encountered. Provision must be made for renewal and replacement with reasonable facility of parts subject to wear and breakdown. Specifications must be carefully prepared for competitive bidding on this equipment if the best possible results are to be secured.

Link-Belt Company has developed a so-called "Roto-Louvre" drier. One unit of this type was added to the Milwaukee, Wis., plant about 7 years ago. The Milwaukee plant also employs 9 direct-indirect rotary driers.

It is understood that Detroit plans the construction of a demonstration unit for sludge incineration with rotary driers.

### Maintenance

It is important to provide suitable lubrication for mechanical equipment. The manufacturers' recommendations should be obtained and followed religiously until and unless experiences demonstrate the need for change. Scheduled periodic inspection with prompt repair or replacement of defective parts as needed, and suitable protective painting of parts subject to corrosion, will prolong the life of the equipment.

A chapter in "The Sewerage Manual," 1943 Edition (1), covers this subject more adequately than would be practical in this paper. The small booklet "Sewage Works Maintenance" (2) also contains many practical and helpful suggestions for operation and maintenance of sewage works equipment.

### Miscellaneous

This paper may well be criticized for omission of discussion of such equipment as meters, controls, sewage pumps, sludge pumps, gas engines, and many other items commonly in use at sewage treatment plants. Possibly each of the subjects enumerated is of sufficient importance and scope to justify a separate paper.

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## DISCUSSION

By Charles R. Velzy

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In the excellent discussion given by Mr. Flood on the application and operation of some of the equipment more widely used in sewage treatment, he has pointed out that his comments largely reflect personal experience and has inferred that the experience of others may have differed from his own. He has also indicated that a discussion might be extended to equipment not covered by his paper. This discussion refers to additional experience with some of the equipment mentioned by Mr. Flood and will comment on some other equipment.

Perhaps a worthwhile objective of these discussions is to encourage further discussion on the part of engineers, operators, and manufacturers. It is obvious that engineers and manufacturers need as much information as possible from the operators on operating problems. It might be helpful, also, to hear from the manufacturers regarding some of the problems of equipment design, in order that the comments and criticisms of engineers and operators may be as constructive as possible.

### Screenings Grinders

It has been stated that the automatic feeding of screenings to grinders may be troublesome where one grinder serves several screens, and that this difficulty is likely to be avoided when there is a separate grinder for each screen. Even this arrangement, at times, may be troublesome. At Buffalo,

N. Y., it was found that at times of storm, and particularly when there were leaves on the streets, the screenings load, even on a single screen, was so heavy that it far exceeded the capacity of one grinder. From this experience it would appear advisable to provide means for disposing of screenings in some manner in addition to automatic feeding to a grinder. If the quantities are not too large the screenings could be stored temporarily and then fed to a grinder at a rate not exceeding grinding capacity.

It appears that there is some virtue in feeding screenings manually to a grinder. Not only can the rate be made to conform to grinder capacity, but it is always possible to remove metallic objects, large pieces of wood, and other material that may either damage the grinder or cause trouble at some other point in the plant.

Some engineers and operators object to any grinding of screenings, taking the position that screenings are a nuisance, and once removed from the sewage should not be returned in any form. It appears that this may be true in some plants, but not in all. It is suggested that the objective of the designer should be to dispose of screenings by the simplest and most economical method. As none of the grinding or comminuting equipment now available will perform a perfect operation, it may be advisable in some cases where the procedure is easy to dispose of screenings without grinding. In other plants, where such disposal is more difficult, it would be advisable to use grinders or comminutors and maintain them in the best possible condition so as to have a minimum of trouble with screenings in other parts of the plant.

## Grit Elevators

A number of devices have been used for elevating grit from grit chambers. Where the lift is not too great, screw conveyors and reciprocating devices on inclined planes have been used successfully. For greater lifts some form of bucket elevator is usually used.

This type of equipment has in some cases given trouble and it appears that its design should be carefully worked out. It is essential that the buckets do not become too firmly bedded or buried in the grit. It is also necessary that it be arranged so that they need not, at any point in their travel, be driven down into the wet grit. A bucket can be lifted vertically a reasonable distance through wet sand, but there is great resistance to horizontal movement when a bucket is buried, and it is practically impossible to pull any form of bucket downward into wet sand.

## Shear Pins

It is interesting to note that there is a tendency to replace the shear pin with some other device for protecting equipment. Although it is an extremely simple device, anyone who has had the privilege of starting the operation of a treatment plant probably has been subjected to the temptation of modifying the shear pin just to keep the wheels moving. Probably very few have successfully resisted all such temptations.

The manufacturer of equipment designs the shear pin carefully to carry the load of normal equipment operation. In starting operation there are numerous factors which may make that load heavier than normal. Many times this is successfully overcome by increasing the capacity of the shear pin. In other cases, changing the shear pin causes failure of some other part of the mechanism.

In sewage treatment equipment some form of protection is essential; there are so many places where obstructions may occur, not only in starting operation, but after normal operation has been established. It appears that the question of the proper type of protection might be the subject of an interesting discussion and may be something on which designing engineers, both in the

consulting office and on the manufacturer's staff will have helpful suggestions.

## Meters

The meter most commonly used in sewage treatment for measuring flow of liquids is the Venturi meter. This meter was first applied to clear water and it has undergone considerable development for application to sewage and sludge. Some have questioned its value, particularly for measurement of flow of sludge.

One of the features of the Venturi tube considered essential in application to clear water, is the piezometer ring. This feature is troublesome in the application to sewage and sludge because it forms a pocket for the deposit of solids. The precision of measurement which the ring is intended to accomplish is far over-balanced, when the liquid carries solids in suspension, by the trouble in keeping the ring clear and the actual interruptions in metering which may result from clogging of the ring and its accessories. A more practical arrangement appears to be the direct connection of relatively large diameter piezometer piping to the throat and upstream sections of the tube. These connections may be made at the ends of the horizontal diameter and thus avoid pockets for collection of solids or gas.

Another development in the tube is in the shape of the throat. In many of the earlier applications of the Venturi tube in the measurement of raw sewage, trouble was encountered from the collection of floating material and gas at the upstream section of the tube. In some cases solids would also collect in the bottom of the tube at the upstream section. The first development was to build tubes with flat inverts. A more recent development keeps both the invert and crown on a straight line, using an eliptically shaped throat.

Sludge is probably more difficult to meter than raw sewage. A piezometer ring is definitely undesirable in the application to sludge. It should be born in mind that constant attention to the meter is a part of routine operation when a Venturi meter is used for measuring the flow of sludge. In general, it may be said that the cost of such continuous attention is not too great a price to pay for the value of obtaining a reasonable measure of the quantity of sludge being handled.

An interesting application of a different type of meter for sludge is the tipping bucket meter built by W. A. Sperry at Aurora, Ill. (1). This form of meter is positive, reasonably accurate, and probably requires less attention than the Venturi meter. It occupies considerably more space, however, and probably would be found practical only in the smaller plant.

## Sludge Pumps

Pumping of sludge is another problem that has taken the time and attention of engineers, operators, and manufacturers. Although the centrifugal pump of the non-clog type is suitable for handling relatively large quantities of sludge, or for handling activated sludge or similar material of low solids content, it usually is not suitable for lower rates of flow or for handling raw primary sludge. For these latter applications, the plunger pump and scru-peller pumps have proven more satisfactory. It is well known that the plunger pump was adapted from the contractor's plunger pump primarily used for dewatering excavations. It was soon found, however, that for handling sludge a number of features required special attention. One of the first questions was the type and characteristics of the valves. The ball valve in a chamber with free and ample passages unobstructed by fins, which would catch fibrous material, was found to be the best type of valve. The quick opening cover for the valve chamber was of course found to be essential.

Another feature, not quite so obvious

perhaps, was the limit on the rate of pumping. Some years ago it was not uncommon to specify maximum pumping rates of 200 g.p.m. for a duplex pump with 4-in. piping connections. At least one manufacturer always insisted, however, that this rate was too high for a pump of this size. This point has been generally accepted and pumps of this type are now usually limited to not over 150 g.p.m.

In order to obtain an adjustable rate of pumping, the earlier designs were equipped with adjustable eccentrics so that the length of stroke of the pump could be changed to vary the rate of pumping. There appears to be some advantage in maintaining the full length of stroke and obtaining variation in the rate of flow by changing the speed of the pump. This can be accomplished by placing a variable speed reducer between the motor and the pump. For the lower rates of pumping, the full stroke results in less slip and smoother operation.

In general, the contractor's type of plunger pump was designed for light pressure. This design in many cases was found inadequate for pumping sludge. Although the static head in sludge pumping is usually not great, conditions sometimes arise which impose relatively high heads on the sludge pump. It is advisable, therefore, to specify that a plunger sludge pump be designed for some head considerably above the static head required. This not only results in a pump suitable for the emergency of high heads but it also provides a sturdier unit, with correspondingly less wear and lower maintenance.

The improvements and changes which have been found worthwhile in adapting the contractor's trench pump to sludge pumping, have resulted in a more expensive pump. The additional cost is justified, however, particularly in the larger plants where the pumps must operate several hours each day.

## Aeration Equipment

It will be interesting to observe the operation of two new devices for applying air to sewage in the activated sludge process. One of these, made by American Well Works and called the "jet aerator," accomplishes the mixture of air with the sewage by the action of a jet of water or sewage arranged to entrain the air in the stream of the jet. The other device, known as the "impingement aerator" and made by Walker Process Equipment, accomplishes the mixture of air and sewage by introducing air at the edge of a specially designed plate, against which a stream of sewage impinges. Both of these devices require a system of piping for distribution of air and another system of piping for the distribution of sewage used in the jet or impingement device. If successful, they will eliminate troubles which have resulted from the clogging of diffusion plates. Another advantage is that the air used with this equipment need not be filtered.

There is still room for additional discussion on equipment used in sewage treatment. Comments on operating experience are always helpful. It might also be worthwhile to hear from the manufacturers on how they have solved some of the problems encountered in designing and building equipment for sewage treatment.

### Reference

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# Industrial Wastes

## BIOCHEMICAL OXIDATION OF DAIRY WASTES. I. METHODS OF STUDY

By Nandor Porges, Janet B. Pepinsky, Nancy C. Hendler and Sam R. Hoover

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Microbial oxidation of dairy waste is being investigated as a possible rapid aeration process for the disposal of such wastes. The composition of dairy wastes varies in total solids from less than 1 per cent to more than 4 per cent of that of milk (1), depending on waste-saving practices advocated by Trebler and Harding (11). The total solids in milk have been reported as 125,000 p.p.m. by Eldridge (2) and 131,500 p.p.m. by Bloodgood (1); hence, a waste containing 1 per cent milk would have about 1,300 p.p.m. total solids, almost all of which are organic solids. The constituents of whole milk vary within wide limits (1) (4); Table I gives the approximate average composition (11). The fat is rapidly coagulated during aeration, and the soluble constituents left are mainly protein and lactose. It was decided, therefore, that a solution of dried skim milk would be suitable for preliminary surveys of the activities of various microorganisms. Table I includes the average composition of dried skim milk and a synthetic dairy waste prepared by dissolving 1 gm. of this product in 1 l. of water. It will be noted that the fat-free organic solids in the milk waste and in the skim milk preparation are 830 p.p.m. for the former and 874 p.p.m. for the latter.

A waste of this type has an average 5-day B.O.D. about 3 or 4 times as great as that of domestic waste. According to Galligan and Levine (5), the treatment of dairy wastes in a disposal plant designed for municipal sewage may cause severe operating difficulties. Moreover, many plants are in communities without facilities for treatment. The high oxygen demand and ready biochemical availability of the protein and carbohydrate of milk indicate the desirability of developing an aerobic treatment specifically designed for milk wastes. In this investigation, the ability of various organisms to alter the B.O.D. under aerobic conditions was followed by determining changes in individual constituents of the waste. Thus, the utilization of the organic constituents for synthesis of cell substance or their partial or complete oxidation could be

TABLE I.—Average Composition of Milk and Dried Skim Milk

| Constituent | Whole Milk (%) | Dried Skim Milk (%) | Solution Containing | |
|---|---|---|---|---|
| | | | 1% Milk (p.p.m.) | 0.1% Dried Skim Milk (p.p.m.) |
| Fat | 3.9 | 0.9 | 390 | 9 |
| Protein | 3.2 | 36.9 | 320 | 369 |
| Lactose | 5.1 | 50.5 | 510 | 505 |
| Ash | 0.7 | 8.1 | 70 | 81 |
| Total Solids | 12.9 | 96.4 | 1,290 | 964 |
| Organic Solids | 12.2 | 88.3 | 1,220 | 883 |

followed. The changes in oxygen demand due to lactose, protein, and nonprotein nitrogenous substances could be followed, as well as the total oxygen demand and pH. The methods used and their application to the problem are presented.

## Methods

*Chemical Oxidation Demand (C.O.D.)*

A rapid chemical method developed by Eldridge and associates (3) and hitherto unpublished has been applied in this study. They conducted B.O.D. tests on fresh and fermented waste prepared from skim milk, with the results shown in Figure 1. On fresh wastes, the C.O.D. was essentially the same as the 20-day B.O.D. The rate curve of the fermented waste differed from that of the fresh waste. The C.O.D. appeared to be comparable to the point on the curve where second-stage oxidation had taken place. Eldridge has obtained additional data showing that with milk wastes, the suggested C.O.D. test appeared to give more consistent and reliable results than the 5-day B.O.D. test. Table II gives results obtained in the laboratory on freshly prepared solutions. The C.O.D. shows good agreement with the 20-day B.O.D. for the milk products tried, but no comparison exists between the 5-day B.O.D. and 68 per cent of the C.O.D. The need of a rapid chemical test that gives reproducible results comparable to those of the B.O.D. test is generally recognized, and methods have been reviewed by Rhame (8) and Ingols and Murray (6). The fairly homogeneous character of dairy wastes permits the use of a chemical method, with satisfactory results. Therefore, the data herein are reported as the chemical oxygen demand, which may be considered for general purposes as the 20-day B.O.D. Details of Eldridge's chemical oxidation method, which is a modification of Rhame's chromic acid method, are as follows:

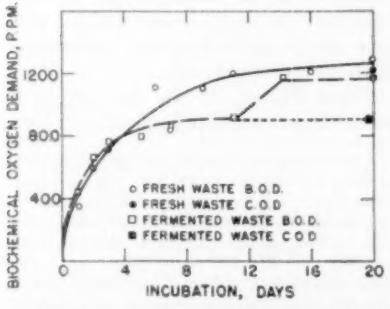


FIGURE 1.—B.O.D. rate curves of fresh and fermented skim milk (see text).

TABLE II.—Comparison of Oxygen Demands of Solutions Determined Chemically and Biologically

| Type of Solution | C.O.D. (p.p.m.) | | B.O.D. (p.p.m.) | |
|---|---|---|---|---|
| | Total | 68% | 20-day | 5-day |
| Skim Milk | 1,052 | 715 | 1,056 | 636 |
| Lactose | 516 | 351 | 519 | 431 |
| Casein | 604 | 412 | 639 | 327 |

Reagents: 1. Dichromate oxidizing agent is prepared by dissolving 2.5 gm. of potassium dichromate in a mixture of 500 ml. each of concentrated sulfuric acid and 85 per cent orthophosphoric acid. Triturating the dichromate with small quantities of the orthophosphoric acid aids solution. The oxidizing agent is filtered through glass wool before it is used.

2. Potassium iodide solution is made by dissolving 55.3 gm. in 200 ml. of water.

3. Sodium thiosulfate, 0.05 normal, is prepared by dissolving exactly 12.41 gm. in water and making up to 1 liter.

4. Soluble starch solution.

Procedure: 1. Place exactly 50 ml. of the dicromate oxidizing solution in a 500-ml. Phillips beaker.

2. Transfer 5 ml. of the waste sample to the beaker.

3. Place the beaker on a hot plate and suspend a thermometer in the flask so that it does not touch the bottom.

4. Heat uniformly; a temperature of 165° to 170° C. should be reached in 5 to 6 min.

5. Immediately remove the beaker from the heat, remove the thermometer and cool the flask. Cooling to room temperature should take about 5 min.

6. Add 200 ml. of distilled water to the beaker and again cool to room temperature in a water bath.

7. Add 10 ml. of potassium iodide solution and titrate immediately with the 0.05 N thiosulfate solution, adding starch near the end point. The color change is from dark blue to pale blue-green.

8. A blank determination using 5 ml. water is run at the same time. All determinations are made in duplicate.

9. Total oxygen demand, in p.p.m., is equal to 80 times the difference in ml. used by the water blank and sample. The calculations are as follows:

$$\frac{D \times 0.05 \times 8}{5} \times 1{,}000 = D \times 80$$

In which $D$ is the difference in reading between the blank and the sample; 0.05 is the normality of the thiosulfate used; 8 is the milli-equivalent of oxygen; 5 is the volume of sample taken; and 1,000 is the conversion to one liter, giving milligram per liter or p.p.m.

*Lactose*

The procedure for determining the oxygen demand due to lactose is essentially the micromethod of Stiles, Peterson, and Fred (10) adapted to this study as follows: Place exactly 15 ml. of waste solution in a 25-ml. volumetric flask and neutralize to phenolphthalein. Add 1 ml. of solution containing 33 per cent basic lead acetate and shake. Remove excess lead by adding 3 ml. of solution containing 10 per cent disodium phosphate, mix thoroughly, and make up to volume. Allow coagulum to settle. Pipette 5 ml. of clear supernatant liquid into a 50-ml. test tube, add 5 ml. microreagent,* stopper with loose-fitting cork, and heat in a boiling water bath for exactly 15 min. Cool rapidly, add 5 ml. N sulfuric acid, shake, and after standing for 1 min. titrate with 0.005 N sodium thiosulfate, using starch as an indicator. A similar determination is made on a water blank. The difference in the two readings is an indication of the amount of reducing sugar present, and the lactose value in p.p.m. is obtained from a graph prepared by using known amounts of lactose hydrate. The major ingredient of the unfermented synthetic waste used in these studies is lactose, amounting to 50 per cent of the total solids. Therefore, in a solution containing 1 gm. of skim milk per liter, 500 p.p.m. lactose hydrate is present. The complete oxidation of this lactose would require 561 mg. of oxygen, or 561 p.p.m. This gives a theoretical factor of 1.123 for obtaining the oxygen demand of lactose, the same as that obtained by the chemical oxidation test. Thus, that part of the oxygen demand due to the sugar can be calculated after the amount of sugar present in the waste is determined.

*Protein*

The procedure for determining the oxygen demand due to protein is based on that of Robinson and Hogden (9), who determined the protein content of blood serum. The intensity of the biuret color is measured at a wave length of 560 millimicrons, and the protein content is obtained by comparison with a reference graph.

Place 40 ml. of the sample in a centrifuge tube, add 2 ml. of trichloro-

* Microreagent: Dissolve 40 gm. anhydrous sodium carbonate in 400 ml. warm water. Now dissolve 5 gm. copper sulfate and 7.5 gm. tartaric acid in about 150 ml. water and add to the sodium carbonate solution with stirring. In 250 ml. water, dissolve 10 gm. potassium iodide, 0.7 gm. potassium iodate, and 18.4 gm. potassium oxalate; then add the mixture to the alkaline copper solution, cool, and dilute to 1 liter.

acetic acid solution containing 2 gm. of acid, mix, and place in a water bath at 60° to 70° C. for 5 to 10 min. Cool in water bath and centrifuge for 15 min. at 2,500 r.p.m. (In the equipment used, this was a relative centrifugal force of 1,700.) Pour off the supernatant liquor. Add 5 ml. of 3 per cent sodium hydroxide to the coagulum and dissolve the protein, using gentle heat if necessary. Add 35 ml. of sodium hydroxide solution; add 1 ml. of 20 per cent copper sulfate solution, stopper, and shake vigorously for 1 min. Let stand for 1 hr.; centrifuge about 10 min. to pack the precipitate, then filter the supernatant liquid through a sintered glass filter of medium porosity, collecting the clear filtrate in a dry tube. Using a 60-mm. cell, determine the density of color spectrophotometrically at a wave length of 560 millimicrons. Convert the reading to protein value by means of a reference graph (Figure 2), in which the density values are related to mg. of protein per liter (p.p.m.) when using a 40-ml. sample.

In establishing the reference graph, 1 gm. of dried skim milk was dissolved in 500 ml. of water. The proteins were precipitated in a 5 per cent concentration of trichloroacetic acid, centrifuged, and collected on a sintered-glass filter. The proteins were dissolved with 3 per cent sodium hydroxide and made up to a liter volume with the alkali solution. Different amounts of this stock solution were transferred to large centrifuge tubes and made up to 40-ml. volumes with 3 per cent sodium hydroxide. The blue color was developed and filtered as above, and the density determined on the spectrophotometer. The nitrogen contents of these blue biuret solutions were determined by microkjeldahl method, and the protein was estimated by the factor 6.25. The values were plotted as shown in Figure 2. The amount of oxygen required for the oxidation of protein was determined by the proposed C.O.D. method on solutions containing known amounts of commercial casein, protein coagulated from casein, and protein coagulated from skim milk. The results ranged from 1.41 to 1.44; the average was 1.42. In the synthetic waste solution containing 356 p.p.m. protein, the oxygen demand was calculated to be 505 p.p.m.

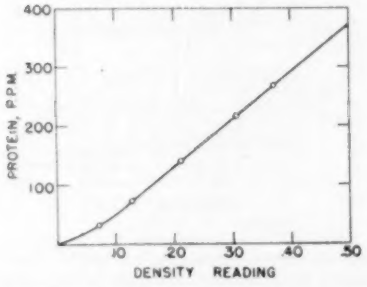


**FIGURE 2.—Relationship between milk protein and biuret density values, as measured spectrophotometrically at 560 millimicron; volume of waste, 40 ml.**

*Nonprotein Nitrogenous Compounds*

Protein determinations made directly on the fresh waste without first coagulating the protein gave values much higher than the protein in the waste. As lactose was the other major ingredient in the waste, a study was made to determine its effect on the protein reading. To different amounts of casein solution, increments of lactose solution were added. Sodium hydroxide was added to give a concentration of 3 per cent in the final 40-ml. volume. The blue color was developed, and the apparent protein values were obtained from Figure 2. Increased values were obtained with increments of lactose in each concentration of protein. The corrections applied when lactose was present are given in Figure 3. Thus, if 125 p.p.m. lactose was present, 70 p.p.m. was deducted to correct for the sugar. An estimation of the

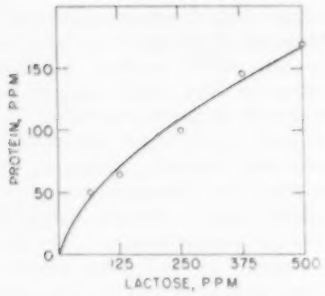


FIGURE 3.—Correction values for biuret-protein values when lactose is present in the solution.

nonprotein nitrogenous substance was obtained in a 20-ml. sample to which 20 ml. of 6 per cent sodium hydroxide were added, and the blue color developed. The correction for lactose was made, and then the protein found by coagulation was subtracted, leaving an approximate value for the nonprotein nitrogenous fraction.

This fraction may be considered essentially as including products of proteolysis, such as peptides, which give a color with the biuret reaction and are closely related to proteins. Therefore, the same conversion factor as for protein, 1.42, has been used to calculate the oxygen demand of this fraction.

*Other Substances*

The sum of the oxygen demands of the lactose, protein, and nonprotein nitrogenous compounds is usually less than the total oxygen demand. In fresh synthetic waste, the difference is small, but as the material is acted on by the microorganisms the difference becomes greater. This fraction includes the oxygen required to oxidize nonnitrogenous cell substances synthesized by the microorganisms; products of lactose breakdown, such as acids; and free amino acids that do not give a color in the biuret reaction, as well as other miscellaneous products of the organisms.

## Experimental Results

Several 400-ml. portions of a solution containing 1 gm. dried skim milk per liter were distributed in a number of 500-ml. gas washing bottles having fritted-glass discs. After steam sterilization, each bottle was inoculated with 20 ml. of a desired culture grown for about 65 hr. in a shallow layer of a similar skim milk solution. These bottles were kept at room temperature and aerated at the rate of 400 ml. of filtered air per minute. Silicone antifoam was added, and the exit tube of each aerator was connected to a sterile flask to collect any escaping foam. At 24-hr. intervals, a complete unit was removed for analyses. The solution was made up to volume, and passed through glass wool, and the necessary amounts were removed for sugar and acid determinations. The insoluble material adhering to the glass wool and to the aerator was dissolved with sodium hydroxide and, after the excess caustic was neutralized with sulfuric acid, was added to the remainder of the solution. The protein analyses and C.O.D. tests were made on this solution. Three series of flasks were

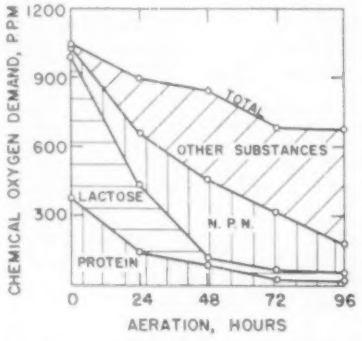


FIGURE 4.—Changes in the proportion and in the composition of dairy waste caused by the aerobic action of *B. polymyxa*. Areas between the curves represent the chemical oxygen demand of the ingredients; that of the whole waste is represented by the total area.

prepared and inoculated with *Bacillus polymyxa, Saccharomyces fragilis,* and a small rod isolated from cow manure. The action of each organism on the constitutents of the waste as measured by the oxygen demand over 96 hr. of aeration has been plotted.

*B. polymyxa* (Figure 4) was selected because of its great proteolytic activity. This action was confirmed on this waste, in which only about 15 per cent of the proteins still remained after 48 hr. Disappearance of lactose was also rapid. The pH at this time was 5.2, but reached 5.8 at 96 hr. The total oxygen demand, however, had decreased only about 21 per cent in 48 hr. and 37 per cent in 96 hr. Although the original ingredients of the milk had disappeared to a great extent, the action was primarily hydrolytic, as significant portions were found in the nonprotein nitrogenous fraction and in the fraction consisting of acids and other metabolic products.

*S. fragilis* acted somewhat differently, as seen in Figure 5. The protein fraction remained fairly constant, being converted to cell substance, as evidenced by the vigorous growth.

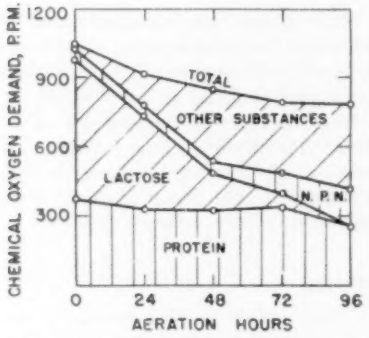


FIGURE 5.—Changes in the proportion and in the composition of dairy waste caused by the aerobic action of the yeast, *S. fragilis*. Areas between the curves represent the chemical oxygen demand of the ingredients; that of the whole waste is represented by the total area.

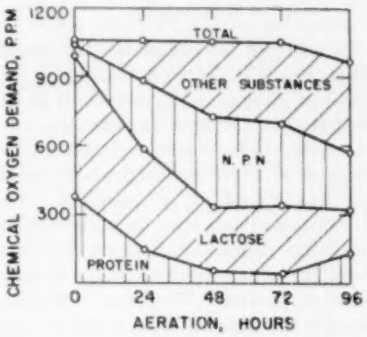


FIGURE 6.—Changes in the proportion and in the composition of dairy waste caused by the aerobic action of a coli organism. Areas between the curves represent the chemical oxygen demand of the ingredients; that of the whole waste is represented by the total area.

Lactose was utilized fairly readily, and the nonprotein nitrogenous fraction remained small. Other substances were produced, and the pH decreased from 5.7 to 5.3. The total oxygen demand had been decreased 26 per cent in this experiment. If the protein were considered as one-half the yeast cell (7) and mechanical means of removing the yeast were used, the expected reduction in oxygen demand would be about 70 per cent. In other experiments, tests made on the supernatant liquid after centrifuging showed a reduction of about 75 per cent in C.O.D.

The third series of aerators were inoculated with a small rod isolated from cow manure, tentatively identified as of the coli group. As shown in Figure 6, there was little change in the total oxygen demand, although the protein and lactose were attacked. At 48 hr., most of the protein had disappeared, but the nonprotein nitrogenous fraction had increased; more than 50 per cent of the lactose had been converted to other substances. At 96 hr., there occurred a slight decrease in oxygen demand, accompanied by an increase in protein.

## Discussion

In a search for organisms and conditions that will decrease the oxygen demand of diluted dairy waste, it is desirable to determine rapidly the constituents of the waste and the oxygen demand of these constituents in addition to the total oxygen demand. The chemical methods used in these studies are fairly rapid and reproducible, and therefore can be used to follow a rapid aeration process. They can determine changes in individual ingredients and their utilization for synthesis of cell substances, or their complete or partial oxidation.

The pollution effect of the dairy waste may be obtained by the C.O.D. test, but the proportional amount contributed by the ingredients of the waste must be determined separately. A decrease in lactose may cause a decrease in total oxygen demand if the sugar is oxidized, or little change may occur if it is converted to other products of similar oxygen demand or if it is used for protein synthesis. Ideally, lactose or its derivatives should be completely oxidized to carbon dioxide and water. In the same way, the protein of the milk may be oxidized to different degrees, and the nitrogen used to synthesize cell protein. It may be hydrolyzed without altering its effect on the total oxygen demand of the waste.

The ideal condition would exist in milk waste with its soluble constituents if the C.O.D. of the waste and its ingredients would converge to zero in a relatively few hours. This can only be approached, as residual cell substance itself has an oxygen demand. Therefore, it becomes necessary to establish conditions that will oxidize much of the waste solubles as completely as possible without the production of other soluble products such as lactic acid, amino acids, etc. In addition, the soluble products not oxidized must be converted to an insoluble form, such as cell substance, which can be readily removed from the solution, leaving an effluent of low oxygen demand. The methods proposed offer a means for following these changes.

## Summary

Methods are given for following the changes in oxygen demand of the major ingredients of dairy waste—protein and lactose—during rapid aeration.

A rapid chemical oxygen demand (C.O.D.) test giving consistent results with dairy wastes is described in detail.

Applications of these methods to the biochemical oxidation of 0.1 per cent skim milk by three organisms for 96 hr. are presented.

The organisms used were *Bacillus polymyxa*, *Saccharomyces fragilis*, and a coli organism.

## Acknowledgments

The authors are indebted to E. F. Eldridge for permission to describe his method for determination of the chemical oxygen demand of dairy waste.

The interest and suggestions of the Task Committee on Dairy Waste Disposal of the Sanitary Standards Subcommittee of the Dairy Industry Committee have been welcome.

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## INDUSTRIAL WASTE TASK COMMITTEE TO BE FORMED

The Water Pollution Control Advisory Board, at a meeting in Cincinnati, Ohio, January 10–11, 1950, adopted in its entirety a proposal by Public Health Service officials to form a National Technical Task Committee on Industrial Waste. The proposal was submitted by C. E. Schwob, chief of the Division of Water Pollution Control, and L. F. Warrick, chief of the Division's Technical Services Branch.

The task committee would act as coordinating agency for a number of major industrial groups composed of industries having allied interests. Each group would consist of representatives from individual industries. As contemplated, the task committee would consist of about 25 persons, but the industrial sub-committees would contain "150 to 200 of the best technical minds in the country."

Functions of the task committee, in line with the Board's previously announced stand that the solution of industrial waste problems is primarily the responsibility of industry, would include: inventorying, appraising, coordinating, and promoting research and developmental work on treatment and control of industrial wastes; stimulating close working relations on technical phases with industry and with Federal, State, and local governmental agencies; and disseminating information on progress made in industrial waste pollution control. The Public Health Service would assist the committee in the role of a clearing house for industrial waste problems.

# CHARACTER OF WASTE OIL EMULSIONS*

By David Milne

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This discussion is confined to a few general observations on some of the things to be considered in breaking the type of emulsion used in metal processing activities. It is limited, therefore, to emulsions in which oil is dispersed in water by means of some emulsifying agent.

Before proceeding directly to the consideration of breaking of emulsions it might be worthwhile to review a few of the characteristics of emulsions and some of the methods by which they are formed. From this basic understanding it may be possible to point out certain weaknesses in the emulsion system and to show that by concentrating the attack on certain points, the emulsion might be broken quite readily.

## Types of Emulsifiers

In the first place, an oil-in-water emulsion must contain three components—the dispersed phase (oil), some emulsifying agent, and the external phase, in this case water. The emulsion is dependent almost entirely for its stability on the type of emulsifying agent used. Therefore, the emulsifier may be considered to be the most important component of the system. The different classes of agents used in the formation of oil-in-water emulsions are as follows:

1. An electrical charge on the surface of the oil particle.
2. Various miscellaneous natural agents, such as proteins, gums, etc.
3. Certain finely dispersed solids, such as the clays, carbon black, etc.
4. An anion active agent, such as a soap.

Few of the emulsions encountered in metal working practice will be prepared by means of imparting a simple electrical charge to the surface of the oil droplets. This type of emulsion is quite commonly found in powerhouse practice, where the condensed steam returning to the power plant is frequently contaminated with emulsified lubricating oil. In some cases even this type of emulsion might be described as one using a soap type emulsifying agent, if the lubricating oil contains saponifiable matter and free alkali is present due to boiler water carryover.

It is not likely that metal working emulsions will be prepared with the natural agents as emulsifiers, due mainly to their cost and general unsuitability for the purpose. These emulsifiers, which include the natural gums (such as karaya and arabic), the starches, and the proteins, find their greatest use in food products, cosmetics, and similar products. A somewhat similar situation occurs in the case of the clay type emulsifiers, and in general it will be found that the emulsifying agents used for metal cutting oils will come under the classification of anion active agents.

These agents normally fall into four distinct classes according to their fundamental chemical composition as follows:

1. The sodium or potassium soaps, which are salts of fatty acids, such as oleic, palmitic, or stearic.
2. The soaps produced by reacting

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the amino compounds, such as triethanolamine, with the fatty acids.

3. The sulfated oils and alcohols, such as Duponol and Orvus.

4. The sulfonated aliphatics and aromatics, such as Santomerse, Aerosol, and Alkanol.

The choice of any particular emulsifying agent for use with the cutting oils will depend to a great extent on the economics of the situation, and in general the sodium soaps are most favorably considered for this use. Where hard waters must be used in the preparation of the emulsion, the need for some degree of calcium tolerance may dictate the use of the sulfated or sulfonated materials to prevent breakdown of the emulsion during mixing. It should be pointed out that the soaps produced from the monovalent alkali metals and ammonium will produce the oil-in-water type of emulsion, whereas the soaps produced by the polyvalent metals such as calcium or aluminum will produce the water-in-oil type of emulsion.

From the foregoing it is obvious that the most important link in the emulsion chain is the emulsifying agent, and it is logical to conclude that any attempt at breaking the emulsion should be directed towards destroying the ability of the agent to emulsify. The point of direct attack, then, is the emulsifying agent, in whatever position it may occupy in the emulsion system. As it has been indicated that the emulsifier is concentrated at the oil-water interface, the breaking of the emulsion will be concerned with certain activities, physical or chemical, which take place on the surface of each oil particle suspended in the emulsion. It might be of interest to examine the nature and extent of this oil-water interface.

Work done by various investigators (1) (2) (3) has indicated that the average drop diameter of an oil particle suspended in water is of the order of $5 \times 10^{-5}$ cm. Using this as a starting point, it can be calculated that the average drop volume would then be of the order of $6 \times 10^{-14}$ c.c., and that the average area of the drop surface would be approximately $8 \times 10^{-9}$ sq. cm. Therefore, 1 c.c. of an oil to be emulsified in water is capable of producing over 15,000,000,000,000 droplets with a total surface area of about 130 sq. ft.

Consider a cutting oil produced in the ratio of 1 part of oil mixed with 19 parts of water to form 20 parts of emulsion. One teaspoonful (8 c.c.) of this material would have an oil surface area exposed to the water outer phase of approximately 520 sq. ft. A gallon of this emulsion would present an oil surface area of almost 6 acres, and a 1,000-gal. tank would offer about 10 sq. mi. of oil surface area.

The theories advanced for the mechanism of emulsion formation are many and varied, and need not be considered here, but it is now generally accepted that the emulsifying agent in these systems is somehow concentrated at the oil-water interface. If we assume that the emulsifying agent used in the above illustration was present at a concentration of 5 per cent of the oil, then in a 1,000-gallon tank of emulsified oil we would have about twenty pounds of soap. This quantity of soap, in order to perform its emulsifying function, would have to be spread over the entire ten square miles of surface area of oil exposed. Consideration of the tremendous surface areas contained within such a small volume, and of the small amount of emulsifying agent needed to form a stable emulsion, will give some appreciation of the magnitude of the problem.

### Physical Breaking Methods

The breaking of emulsions may be accomplished in several ways, depending on the type of emulsion. Methods for breaking may be described under two headings—physical and chemical. Under the general physical methods available are:

1. Electrical, in which charged plates are immersed in the system. Oil droplets usually possess a negative charge and are attracted to the positive plate, where the charge is removed, the droplets combine, and the oil floats to the surface.

2. Temperature change. Boiling the emulsion has been resorted to frequently as a means for breaking. Emulsion may also be broken by freezing.

3. Addition of an excess of the dispersed phase. In the case of "soluble" oil emulsions this would involve addition of more of the "soluble" oil.

4. Distillation. Separation of the oil from the water by distilling off the water phase.

5. Centrifuging. Emulsions may sometimes be separated in a centrifuge. An example of this would be the separation of cream from milk.

6. Ultrasonic vibration through subjection of the emulsion to high frequency sound vibration. This method has been used both to prepare emulsions and to break emulsions. The method is comparatively new and requires further study.

7. Agitation. Emulsions may be broken simply by vigorous agitation, as, for example, in the formation of butter.

8. Filtration through adsorbent media. Emulsions may sometimes be broken and the oil phase removed by filtration through materials such as coke or diatomaceous earth.

9. Addition of a liquid in which both phases are soluble.

10. Sedimentation. Certain emulsions may be broken simply by allowing them to stand undisturbed for long periods of time.

Most of the physical methods may be ruled out immediately from the standpoint of convenience or cost, and indeed the only method in this group showing some promise for the treatment of emulsified oils is the filtration method using coke or some other absorbent material. Ultrasonic vibration has not been investigated thoroughly for this application.

### Chemical Breaking Methods

Under the classification of general chemical methods of breaking emulsions are found:

1. Reaction with salts of polyvalent metals.

2. Salting out the alkali soaps.

3. Destruction of the film of emulsifying agent by mineral acids, ether, etc.

The chemical methods for emulsion breaking appear to be the most satisfactory, and in each case it will be noticed that the chemical attack is directed towards the emulsifying agent.

Inasmuch as the emulsion can be broken by reaction of the alkali soaps with polyvalent metals, this may present the easiest and most convenient method for disposal of the emulsion. It has been noted (4) that addition of quantities of the polyvalent metals equivalent to the amount of sodium oleate present results in breaking of the emulsion. In some cases, however, breaking the emulsion by adding an excess of a divalent salt (calcium or magnesium) has resulted in the formation of the opposite type of emulsion, especially if large quantities of oil are present. This inversion does not take place if the trivalent metals (aluminum) are used, due apparently to the very low emulsifying power of the aluminum soaps.

Emulsions have been broken by simply adding enough electrolytes to salt out the emulsifying agent. This may be done, for instance, by the addition of sodium chloride to an emulsion containing sodium oleate as the emulsifier. In general, however, large quantities of sodium chloride are necessary, and if the clarified solution remaining

still contains large quantities of dissolved salt, it would still be objectionable from a trade waste disposal standpoint.

The addition of a mineral acid such as sulfuric acid would tend to break up the emulsifying agent simply by forming the fatty acid plus sodium sulfate. The fatty acid itself would be insoluble in water, and would either precipitate or go into solution in the oil phase. Because the emulsifying agent would be destroyed by the addition of this acid, the emulsion no longer would be stable and would tend to separate.

### Effect of Water Hardness

Consideration of the fact that the divalent metals will cause separation of an emulsion brings up the very common experience of the breakdown of oil emulsions when mixed with water of varying degrees of hardness. As an example, examination of the analyses of Detroit (Mich.) water and of the water now being obtained from the wells in the Kalamazoo area, with respect to their calcium and magnesium content, shows the following:

| Component | Detroit | | Kalamazoo | |
|---|---|---|---|---|
| | P.P.M. | Equiv. per Mil. | P.P.M. | Equiv. per Mil. |
| Calcium | 27 | 1.35 | 100 | 5.0 |
| Magnesium | 7 | 0.6 | 36 | 3.0 |
| Total equivalents | | 1.95 | | 8.0 |

If it be assumed that an oil emulsion is made up using 3 per cent sodium oleate as the emulsifying agent, it is found that on dilution of the oil, 1 part to 99 parts water, there is 1 equivalent of sodium oleate per million present. Obviously, if Detroit water was used to make up this emulsion, the amount of calcium and magnesium present (1.95 equivalents per million total) would exceed the amount of sodium oleate, and would remove the sodium oleate from solution as insoluble calcium and magnesium oleate. This would result in a partial breakdown of the emulsion, and, in fact, could result in some inversion of the emulsion so that a small amount of water in oil emulsion would result. If this dilution were practiced with Kalamazoo water, almost certainly the entire emulsion would be precipitated. Even if an oil emulsion of 1 part of oil in 20 parts emulsion were prepared using Kalamazoo water, it would be necessary to use over 5 per cent sodium oleate to make sure of having an excess amount of this particular emulsifying agent over that which would be used up by the hardness-producing ions. These figures should indicate the extreme importance of water hardness in the preparation of emulsions of cutting oils. Quite frequently it has been noticed that emulsions prepared using hard city water have been unstable, and that after a short period of use the oil phase has separated, and the emulsion is no longer fit for use.

### Summary

This discussion has touched very lightly on some of the things to be considered in the breakdown of emulsions wasted from metal cutting operations. Emulsion technology and the theory of emulsions are two vast and complex fields. It has been possible to review only in a very limited manner what could be expanded into a lengthy and highly technical discourse. Certainly, more must be known about the physical reasons for the stability of an emulsion before we can successfully and economically destroy it, and with the increasing pressure being placed on industry to find the answers to its waste treatment problems, these fundamental data should soon be available.

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## SYNTHETIC DETERGENT USAGE IN BRITAIN

An assessment of the total tonnage produced is by no means a measure of the amount of synthetic detergents with which sewage treatment facilities will have to deal, according to A. L. Waddams, of Shell Chemicals Limited, in a paper presented at a meeting of the London Branch, Institute of Sewage Purification (England), on January 14, 1950. This situation, Mr. Waddams pointed out, results from a number of diverse industrial applications of synthetic detergents that ensure the material never reaching the sewers and account for quite a significant tonnage of detergent.

In England, the largest share (75 to 80 per cent) of the total production of synthetic detergents is consumed in household usage. Domestic soap consumption has dropped from a pre-war level of 400,000 to 450,000 tons annually to about 300,000 tons. The equivalent of about 40,000 tons of soap per year is now being consumed in the form of household synthetic detergents, with more than half that total being used in the Greater London (hard water) area.

Industrial usage of soaps, although much smaller than domestic consumption, has not suffered any very significant diminution since before the war. The largest industrial soap users are the laundry and textile industries, which are also the largest component of the total industrial usage (100,000 tons annually) of synthetic detergents. Significantly, these industries have been kept well supplied with soaps during the war-induced shortage, but technological and economic advantages gained by the use of synthetics have won them their market in this field. By no means all of the synthetic detergents used industrially are replacing soap. There are specialized processes in which the wetting, penetrating, and dispersing actions of the synthetics are required, rather than their detergent properties.

The present total production of synthetic detergents in England is more than 50,000 tons per year. This figure, Mr. Waddams pointed out, is likely to see quite a substantial increase. The figures may be compared with the equivalent American figures, bearing in mind the fact that soap rationing does not exist in America. Total consumption in the U. S. in 1948 is estimated to have been about 350,000 to 400,000 tons of marketed product. It is anticipated that the consumption may in the future rise as high as double this amount.

# EXTENDED USE OF OIL EMULSIONS TO MINIMIZE DISPOSAL PROBLEMS *

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To appreciate the relative importance of oil and water emulsion grinding coolant at New Departure's Sandusky, Ohio, plant, a bit of background information is in order. The New Departure Division of General Motors is the country's largest manufacturer of ball bearings. It operates three plants; one each in Bristol and Meriden, Conn., and a new plant in Sandusky, Ohio. In the manufacture of ball bearings approximately one-half the employees are occupied on grinding operations. Incidental to such extensive grinding operations there is the necessity for a central coolant system for the original mixing of water-soluble or other solutions used as a grinding coolant, and to which the coolant is returned from the grinders. Sludge is also removed from the circulated coolant and continuous conditioning is performed for re-use. New Departure's experience with reconditioning grinding coolant has involved three major methods—burlap bag filtration, suction spring cleaning, and the flotation principle.

## Bag Type Cleaning System

For many years the method of removing sludge, consisting of steel and abrasive particles, wheel-bond, and other impurities, was to pass the dirty coolant through burlap or other textile bag-shaped screens, trapping as much as possible of the sludge. This was usually accomplished by gravity feed, the supply to the bags requiring constant adjustment to get the maximum use from the bags and still prevent overflowing of the dirty coolant to the clean coolant storage tank, generally below the bags. Further cleaning of the solution was accomplished by designing the storage tank large enough to maintain a detention period permitting further settling of solids. It was found necessary to remove the solids from the bottom of the tank periodically. Various methods were tried in an effort to prevent rancidity and to control bacteria colonization. During periodical cleaning the solution was pumped to a sterilizing tank, where heat was applied for a prescribed amount of time before returning to the system. At one time, even irradiation of vitamin D was given a trial, utilizing ultra-violet light through glass tubes in a recirculating system.

The results of this method were inconstant due to the nature of the screen medium, and to the viscosity of the coolant, which varied in proportion to the time it had been in use. The burlap filter bags naturally passed greater quantities of solids when new and clean than after a filter bed of the sludge being removed had been built within the bags. The degree of cleanliness accelerated from the time of the installation of the clean bag until just prior to the time that the bag required servicing because it would no longer pass coolant through the cake of solids that had been established.

The method of servicing the bags was to stop off the supply of coolant to an individual bag, allow it to drain

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as much as possible and then further "milk" it by twisting until all moisture possible had been removed. Following this the contents of the bag were dumped into a refuse container, the bag was turned wrong side out, shaken to remove all loose particles, turned right side out again, and replaced in a rack under the spigot supplying it.

*Health Hazards*

The procedure, where an operator's hands were continuously immersed in the solution or grinding sludge, was decidedly unsanitary, for everyone knows what happens in grinding departments when operators have no other place to spit or get rid of cigarette butts, chewing gum, etc. It was also evident that a further health hazard was contributed when viewing the hands of the operators who had been on the job for any appreciable time. In the milking and wringing process tiny steel particles that embedded themselves in the skin of the operators' fingers occasionally caused infection and apparently contributed to a "mushrooming" of the ends of the operators' fingers.

Periodically, the coolant built up curds to a point where various spray jets at machines and at other orifices through which it passed became plugged, causing heavy plumbing maintenance requirements throughout grinding areas. The curds, formed mostly of soluble oil which had broken down from the emulsion, were sufficiently adhesive to attach themselves to the walls of conductors and attract sludge particles to form a coating and continual build-up requiring scraping and cleaning of even the largest mains through which it is passed. Compared to today's methods of handling coolant both the operating costs and connected maintenance requirements were large contributors to the cost of grinding.

This method of cleaning large batches of water-soluble oil coolant was the only one commonly used from the early days of central coolant systems until about 1939. Its over-all efficiency from the point of removal of suspended solids, however, was satisfactory to most grinding operations. Where further clarification was necessary it was done through centrifugal, magnetic, and other types of purification.

## Suction Spring Filtration

The suction spring filtration method of removing solids was developed during the decade 1936–1946. Spring filtration employed banks of tension coil springs, each spring being about ½ in. in diameter by approximately 4 ft. long, wound of stainless wire 1/16 in. or less in diameter. The opening between the wires was controlled by tension applied at the top end of the springs by means of nuts on threaded rods. Each spring was fastened over a hole in a common suction manifold at the bottom. Two or more manifolds formed a bank, which was suspended in the receiving compartment with a sufficient number of similar banks to permit passage of the designed volume of coolant. To remove the settled solids from the bottom of the tank there was a double chain scraper conveyor, which dragged the sludge up an inclined end of the tank, squeezed it to remove moisture, and discharged it into portable hoppers for disposal.

Suction, induced by centrifugal pumps whose suction inlets were connected to headers in which the manifolds of the spring-banks terminated, pulled the coolant through the openings between the spring coils and discharged into the clean compartment of the tank. The suction pumps had designed capacity to exceed the job requirements, so there was a continual overflow from the clean compartment back to the settling area.

*Backwashing*

All particles of a size greater than the openings between the spring coils

were stopped on the outside of the springs. When these solids built up to a point where pump delivery was affected, it was necessary to backwash. This was accomplished by manipulation of valves to reverse the flow of coolant through the springs, i.e., from the inside out. Following experimentation, in the early stages of operation, it was found that this action did not afford sufficient turbulence to remove the gummy deposit of sludge from the springs. Therefore, compressed air was introduced to assist the reverse flow of coolant.

Performance of the unit, and the proper time to backwash, was decided by watching the volume being returned from the clean tank, as well as by observation of the vacuum indicated on gauges. As there was always a large quantity of coolant in the pipe and trough system external to the unit, it was necessary to watch carefully the level in the dirty compartment. If the filter pumps failed to deliver sufficient quantity to the clean compartment, the job supply pumps would lower the level in the clean tank; then the return from the grinding machines would raise the level in the dirty compartment to reverse the flow over the baffle between tanks. The ever-present dirty scum floating in the receiving compartment would then enter the system and cause trouble at the grinding machines throughout the plant.

With the spring suction pumps mounted above the solution level, performance dropped appreciably when dirt accumulation on the springs caused a vacuum exceeding 20 in.; delivery stopped at 25 in. unless the pump stuffing-boxes were perfectly packed and well lubricated. Performance declined in direct proportion to the looseness of the packing.

*Periodic Cleaning*

Due to the nature of the sludge adhering to the outside of the springs it was impossible to clean the springs thoroughly by backwashing. A continual build-up of a gummy substance took place to a point where a thorough cleaning was required. This necessitated removal of the spring-banks to a large tank, where they were soaked in boiling alkali and water for a period. Following this they were broomed thoroughly and rinsed with steam and water hoses before being returned to the tanks.

By backwashing one bank at a time, on properly planned cycles, the volume delivered to the clean tank was not seriously affected. When it was necessary, however, to clean the tanks thoroughly as described, it was found that this chore must be covered during weekends.

*Health Hazards*

The dirty scum floating on the solution in the receiving compartment, together with the tranquility of the solution caused by the planned long detention period for settling purposes, set up ideal conditions for the colonization of various bacteria. Dermatitis cases mounted, and were traced by the medical department to the grinding coolant. Proportioning pumps were employed to introduce germicidal chemicals into the returning coolant, to no appreciable advantage. It finally became a custom to waste the entire batch of coolant to the sewer periodically. This was done partly to alleviate the bacteria condition and partly because of the obnoxious odor of the coolant when it became rancid.

The performance of the system in removing solids from solution was probably as good or better than the previous method using burlap bags. It also appreciably lessened the manpower required for attending the unit, even with the weekend cleaning considered.

## Flotation System

About 1944 a method was developed of removing suspended solids from emulsions and solutions by a "flota-

tion" process. Contrary to the usual conception of removing solids by settling, this process brings the solids to the surface of the solution, where they are removed by skimming. Two of these units installed at the Sandusky plant in 1946 are still in use.

Each unit consists of a settling tank equipped with a double chain and scraper sludge remover; two centrifugal pumps to supply 750 g.p.m. of the settled coolant to each of two clarifying cells where rotor-stators driven by 5-h.p. motors elevate the suspended solids to the surface to be skimmed to overflow troughs and thence back to the settling compartment. Effluent from the cells discharges to the clean compartment, where it is pumped to the system supplying the grinders. The designed rating of the units is 750 g.p.m. each. The only maintenance to date has been necessary repairs to the sludge removing conveyors, and one replacement of V-belts driving the rotors. Total connected horsepower at each unit is 10⅔, excluding the service pumps. The quoted price in October, 1945, was $22,443 for the two units, having a combined capacity of 1,500 g.p.m. and a storage volume of 16,000 gal. No compressed air is required.

The units were first started more than two years ago, and the original batch is still in use. A laboratory check on May 16, 1949, of a sample of coolant taken at the point of delivery at a grinding machine showed less than 0.4 per cent settleable solids in solution. The coolant still has a milk-white appearance, and there is no appreciable odor.

*Health Record*

Hospital records indicated an average of less than two dermatitis cases per month during the last six months treated on employees who come in contact with the coolant. At present an average of 400 employees come in direct contact with the coolant, most of whom have their hands in the solution (in placing and removing parts from grinding machines) at least 20 per cent of the time. Added to this number there are approximately 100 inspectors who handle parts while still moist. Although the feature was not considered at the time of original purchase, the beating action of the rotors in the flotation cells apparently introduces sufficient oxygen to the solution to properly aerate the coolant against rancidity and bacterial colonization. This is a fortunate circumstance, as periodical wasting of the coolant would create problems at the industrial waste disposal plant, as well as adding replacement cost to the grinding operations. Control of skin diseases is, of course, another worthwhile feature.

The only limitation of the system is that the solution being cleaned must be of a nature that will cause a bubbling action when beaten with the rotating blades of the flotation cells. If a froth can be created in this manner, solids will be removed.

## Emulsions as Washes

In the interest of conservation of water as well as soluble oil, consideration is given every use to conserve soluble oil emulsions elsewhere in the plant. It has been found that many washing operations can be accomplished by using a soluble oil and water emulsion instead of the usual alkaline solutions. Although the acceptable washing solution is approximately 10 per cent oil, whereas the grinding coolant is held at 3 to 4 per cent, periodical return of this solution to the grinding coolant central unit has no adverse effect when put to re-use as a grinding coolant. The dilution is such that the 16,000 gal. in use are not affected appreciably percentage-wise. Initial charge and makeup at these washing

machines is accomplished by using the weak emulsion from the grinding coolant system, adding soluble oil as required. Makeup due to dragout at the washing machines partially reduces the volume at the central system, but this localizes the point for adding water rather than having an individual city water connection at each washing machine. As the makeup at the washing machines is controlled by float valve, it also assures that any added liquid is at least partially charged with rust inhibitor.

### Automatic Screw Machines

The majority of the automatic screw machines at New Departure are now using a 4 per cent soluble oil solution for a cutting coolant. These machines have self-contained coolant circulating systems with no attempt made at reclamation. Some freshening is caused here by make up, which again is drawn from the main grinding coolant system. Due to the small quantity in circulation within these machines, however, and coupled with the fact that there are large quantities of hydraulic and lubricating oils introduced into the solution by way of leakage from the machines, this coolant quite frequently becomes curdled and rancid. At such times it is sumped from the machine bases and carted to a large storage tank, where the foreign oils are skimmed and reclaimed. The soluble oil and water emulsion, however, is in such poor condition that the salvage value would not justify reclamation costs. This is practically the only oil and water emulsion wasted from the manufacturing area to the industrial waste disposal plant, where it is treated with other industrial wastes before being released to the sewer.

### Amount of Losses

Due to such natural losses in grinding as splash, carry out, etc., plus the loss at washing machines from dragout and the waste from the screw machine department, it has been necessary during peak 24-hr. operation to add as much as 2,500 gal. of water and 100 gal. of soluble oil. A very small part of this loss may also be considered to be in the 162 cu. ft. of sludge removed from the grinding coolant system in 24-hr. peak operation.

Costwise, the system has been found to be very economical. There is no constant attention given to the operation of the unit. It is observed 10 to 12 times during a 24-hr. period and occasionally minor adjustments are made to the weirs controlling the skimming level. These 10 or 12 visits total not more than 3 hr.

### Summary

To summarize, it has been found that the best present method of extending use of emulsions to minimize disposal problems is to see that they are properly aerated and kept in motion as much as possible; to bleed from the system as much emulsion as possible for other uses in an effort to freshen the solution through makeup; and to utilize the flotation unit for reclamation of, along with the grinding coolant, spent washing solutions and emulsions used elsewhere, which normally would be wasted from the plant.

Plant personnel at New Departure consider themselves extremely fortunate to have accomplished so many of these results and at the same time to have decreased maintenance and operating costs far beyond those formerly in use which contributed to disposal problems as well.

# THE EFFECT OF CHROMIUM ON THE METHANE FERMENTATION OF ACETIC ACID

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Biological activities occurring in the aerobic or anaerobic stabilization of sewage necessitate close control on the introduction of bactericidal substances into the process. Heavy metals are considered of prime importance in this respect, numerous studies having been made on the effects of heavy metals on pure cultures of bacteria (1) (2) (3) (4).

Recent industrial expansion has resulted in increased use of chromium compounds in plating, tanning, and other processes, which in turn has created a serious sewage treatment problem. Unfortunately, the available literature on the effect of chromium on the sewage treatment process is meager. In particular, the influence of chromium compounds on the anaerobic digestion of organic matter has received little attention.

Monk (5) concluded, on the basis of experimental evidence with a pure culture of *A. aerogenes* and some trial runs on a sewage treatment plant, that 50 p.p.m. of chromate (26 p.p.m. Cr) is a safe concentration to discharge into a sewage treatment system. He also observed the accumulation of chromium compounds in the sludge.

Spencer (6) found that chromium plating waste in sewage practically sterilized a filter bed. The chromium concentration of this sewage was 29 p.p.m. Further studies permitted the statement that a level of 10 p.p.m. of chromium as chromate has an almost complete sterilizing effect on sewage purification, and that a concentration as low as 1 p.p.m. of hexavalent chromium is sufficient to retard biological purification. He observed that oxygen uptake is decreased in the B.O.D. test due to the toxic action of chromates on the bacterial flora.

Jenkins and Hewitt (7) came to the conclusion that oxidation of organic matter and ammonia by a filter bed is impaired by 1 p.p.m. Cr (as $K_2CrO_4$) in the sewage. However, even at 100 p.p.m. Cr, 84 per cent oxidation of the organic matter is obtained. Nitrification ceased when sewage containing 4.5 p.p.m. Cr (as $K_2CrO_4$) was added continuously for two days on a percolating filter. A recovery period of approximately 10 days was required for nitrification to start again. Also observed was the chromate effect on the B.O.D. test and the interaction of sewage solids and chromium resulting in a grayish green deposit, which was high in chromium content.

Wells (8) describes the effect of chrome waste (presumably chromate) on an activated sludge plant wherein the sludge was further digested by anaerobic process. Only 15 per cent removal of total solids was obtained. The chromates caused high dissolved oxygen values and low B.O.D. results.

Graham (9) discusses the available literature on the chromium waste problem and suggests that reduction of the hexavalent to the trivalent Cr should be carried out prior to sewage disposal of the waste. The lower toxicity of the chromic salts as compared to chromates, in addition to maintaining them in low concentration, should allow normal sewage treatment operation.

Ross (10) also points out the advisa-

bility of reducing the toxic hexavalent Cr in trade waste before discharging into the sewer system. Chromium loadings of 1 p.p.m. did not seriously affect the operation of an activated sludge process except to produce a slight discoloration in the final effluent.

The problems encountered in copper-containing waste are analogous to those in chromium-containing waste (11). Both react with sewage solids and form sludges containing high concentrations of the metals. Sludges containing 200 p.p.m. precipitated chromium reduced the rate of digestion. Continuous loadings of chromium in excess of 1 p.p.m. can be expected to decrease the efficiency of sludge digestion.

Edwards and Nussberger (12) describe the effect of more than 2 tons of chromic acid on an activated sludge process. The waste was processed in an 18-hr. period. They report little effect on the treatment except that nitrification ceased for 10 days. The effluent B.O.D. was decreased. A high turbidity existed in the effluent for several days, probably due to dead organisms. No decrease in amount of volatile solids or gas production was noted at the digestion tanks. The actual soluble chromium concentration was not reported, but it was well diluted in the digestion tanks.

The paucity of data on the effect of chromium compounds on the anaerobic digestion process instigated this investigation. Using the continuous anaerobic fermentation technique, the effect of $CrCl_3$ and $K_2CrO_4$ on the rate of the methane fermentation was studied.

## Experimental Methods

The anaerobic fermentation of acetic acid to carbon dioxide and methane (13) (14) was carried out in fermenters (15), which allowed continuous quantitative gas collection. A specially adapted side arm on the fermenter permitted the introduction and removal of solutions while maintaining strict anaerobiosis. This was achieved by means of a vaccine bottle rubber stopper placed in the side arm and through which a hypodermic needle could be inserted.

The fermentations were started in a medium (16) of the following composition:

| | |
|---|---|
| Calcium acetate ..... | 10.00 gm. |
| $K_2HPO_4$ ..... | 0.40 gm. |
| $NH_4Cl$ ..... | 1.00 gm. |
| $MgCl$ ..... | 0.10 gm. |
| Tap water ..... | 1,000.00 ml. |

To each 100 c.c. of this medium there was added 3 c.c. of a solution containing:

| | |
|---|---|
| $Na_2S : 9\ H_2O$ ..... | 1.00 gm. |
| $Na_2CO_3$ ..... | 5.00 gm. |
| Distilled water ..... | 100.00 ml. |

The medium was adjusted to a pH of 6.8 with 1N HCl. Washed and ignited asbestos was used as a nidus in the fermenter.

The fermenters were inoculated with 15 ml. of overflow liquor from an anaerobic digestion tank at a local sewage treatment plant. The total volume of solution was 280 ml., and it was kept at this level throughout the period of the study. A gas collecting column was attached to the fermenters, which were then allowed to incubate at 37° C. Within 24 hr. gas production became evident in the fermentations. The calcium acetate substrate was allowed to ferment practically to completion before daily feedings of acetic acid were started.

Prior to the introduction of any toxic metals into the fermentations, they were subjected to a period of stabilization. When the rate of gas production was quantitatively commensurate with the daily acetic acid feed the fermentation was considered "stabilized." Control fermentations have been stabilized and maintained on a continuous daily feed of 0.2 gm. acetic acid for periods in excess of 6 months without any decrease in the rate of gas produc-

tion. The average stabilization period to acetic acid was 25.4 days in these experiments.

The salts of trivalent and hexavalent chromium ($CrCl_3$ and $K_2CrO_4$) were investigated for their effect on the rate of fermentation of acetic acid. Aqueous solutions were made so that the desired concentration per feed period was contained in 1 ml. of distilled water. The same principle was followed in the preparation of the acetic acid feed solution. In this case, the dilution was made with distilled water containing the inorganic salts in the same concentration found in the medium. Nitrogen (as $NH_4OH$) was added at the rate of 6 mg. per gram of acetic acid (17). Before each feeding a small volume of fermentation fluid was removed to compensate for the volume of feed solution to be added. Gas measurements and feedings (if required) were carried out every 24 hr. H-ion concentrations were obtained by means of a Beckman pH meter.

The analytical methods used for quantitative determinations of trivalent and hexavalent chromium in sewage were reported and discussed by Graham (9). They depend on the development of a reddish violet color on interaction of hexavalent chromium and diphenyl carbazide.

## Experimental Results

A study was made of the effect of trivalent and hexavalent chromium on active methane fermentations of acetic acid. The chromium compounds were added in varying concentrations, depending on their effect on the rate of gasification and on the purpose of the particular experiment in question. Trivalent chromium was added as $CrCl_3$; hexavalent, as $K_2CrO_4$. The fermentations were stabilized to the acetic acid substrate prior to testing the effect of the heavy metal on them. The concentration of the substrate was maintained in slight excess to obviate any depression in rate of gas production due to substrate depletion. The treatment of the individual fermentation is described below.

*Digester 9:*—Trivalent chromium (as $CrCl_3$) was added in doses of 1 p.p.m. daily for 18 days and at 2 p.p.m. daily for 10 days without any detrimental effect. However, 10 p.p.m. each day for two consecutive days caused an appreciable drop in the rate of gas production. At intermittent loadings of 5 to 10 p.p.m. the fermentation was kept in operation at a decreased rate for 4 months. The final concentration of chromium reached was 282 p.p.m.

*Digester 8:*—The fermentation received 50 p.p.m. trivalent chromium (as $CrCl_3$) and 10 p.p.m. each day thereafter for 5 days. The last 10-p.p.m. dose added caused a decrease in the rate of gas production. Further dosages of 10 p.p.m. on alternate days for 20 days allowed gasification to continue at approximately half the rate obtained during the stabilization period.

*Digester 10:*—Trivalent chromium (as $CrCl_3$) in 10-p.p.m. daily doses for 7 days resulted in decreased activity on the addition of the last dose. Further loadings of 10 p.p.m. trivalent chromium every 2 or 3 days were continued until the chromium concentration had reached 510 p.p.m. Although the daily rate of gas production was slower during this period (as was the case with digester 8), the total gas return from the substrate fed was 96 per cent of the theoretical value.

*Digester 12:*—A single dose of 150 p.p.m. chromium (as $CrCl_3$) did not decrease the daily rate of gas production over an observation period of 6 days. A second addition of 100 p.p.m. caused a drop in activity persisting for 14 days. After 9 days of normal operation a dose of 100 p.p.m. only caused a slight decrease in the activity of the fermentation. Another 100-p.p.m. dose in 6 days decreased the daily rate of gas production. Normal operation was resumed after a rest period of 10

days. The fermentation was fed acetic acid daily for 5 days of normal operation. At the end of this period a dose of 100 p.p.m. caused a drop in activity persisting for 25 days. After recovery the fermentation was discontinued. The total trivalent chromium added was 550 p.p.m. and the total gas production was 95 per cent of the theoretical expected from the substrate fed.

*Digester 9A:*—The initial chromium dose was 175 p.p.m. Cr (as $CrCl_3$). This was followed by 4 small doses of 5 p.p.m. each (see Figure 1). A slight decrease in activity was detected. After ten days of normal operation (39th to 49th day) a single dose of 100 p.p.m. Cr caused a decrease in the daily gas production. Approximately 11 days later full activity was resumed. At this time, analysis of the fermentation liquor showed that only 1 p.p.m. Cr remained in solution. A dose of 50 p.p.m. after 6 days of normal operation produced another decrease in the rate of fermentation. Four days after this addition the soluble Cr concentration was only 3 p.p.m. The fermentation was allowed to resume normal activity and was then discontinued. The quantitative data on feed, gas production, and chromium dosage were as follows:

| | |
|---|---|
| Substrate fed (as acetic acid) .. | 13.61 gm. |
| Gas production (theoretical) ... | 10,154 ml. |
| Gas production (actual) ..... | 9,672 ml. |
| Gas return ..... | 95% |
| Total trivalent Cr added..... | 345 p.p.m. |

*Digester 2:*—A single dose of 200 p.p.m. Cr (as $CrCl_3$) did not produce an appreciable change in daily rate of gas production. Four days later the soluble chromium concentration was

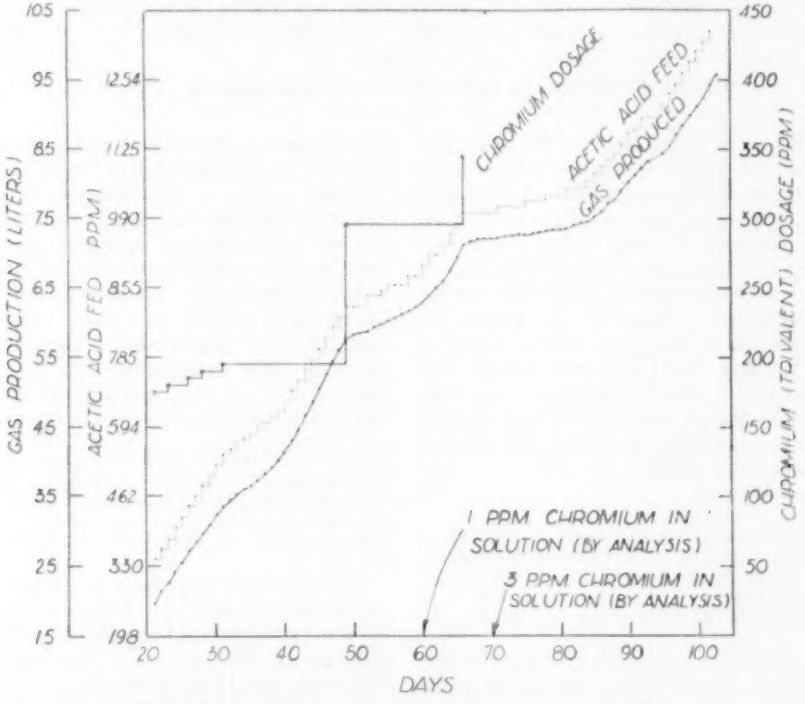


**FIGURE 1.—Effect of trivalent chromium (Digester 9A).**

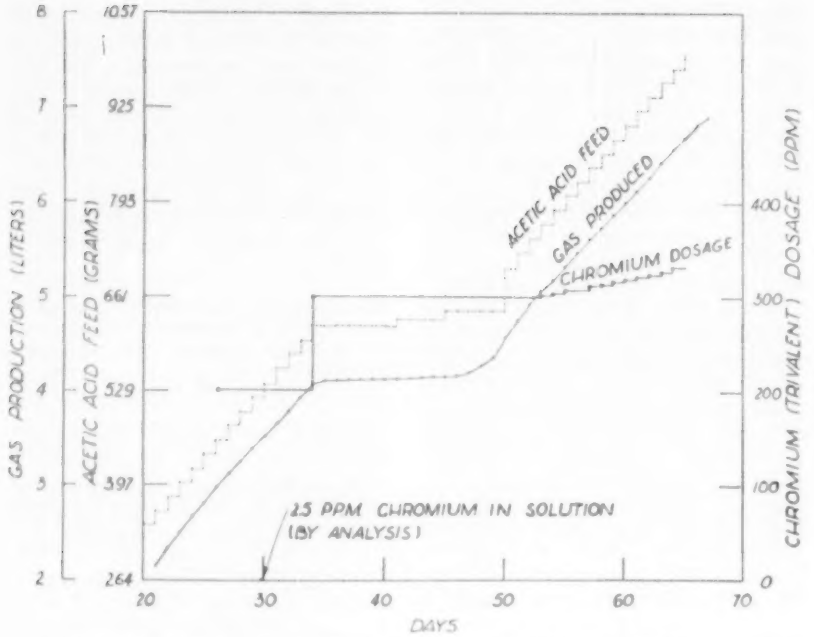


FIGURE 2.—Influence of daily trivalent chromium additions (Digester 2).

found to be 2.5 p.p.m. The next dose of 100 p.p.m. was made 8 days after the first large single dose. An immediate drop in rate occurred, which persisted for 15 days. After normal operation had been resumed, the effect of small daily doses of chromium was determined. Doses of 1.5 p.p.m. increased to 3.5 p.p.m. over a period of 13 days were tolerated without any effect on the rate of gasification. The quantitative data on feed, gas production, and chromium dosage for the full operation period (see Figure 2) were as follows:

| | |
|---|---|
| Substrate fed (as acetic acid) .. | 10.07 gm. |
| Gas production (theoretical) ... | 7,317 ml. |
| Gas production (actual) ..... | 6,879 ml. |
| Gas return ..... | 94% |
| Total Cr added (as $CrCl_3$) .... | 334.5 p.p.m. |

*Digester 3*:—After stabilization, 200 p.p.m. Cr (as $CrCl_3$) was added to the fermentation. This treatment resulted in a decrease in the anaerobic digestion activity. A concentration of 1.6 p.p.m. Cr was found in the fermentation liquor 4 days after the dose had been added. After normal operation had been resumed small doses were added to the digester daily. Gasification continued at a normal rate when daily doses of 3 to 6 p.p.m. were added for 16 days. The quantitative data (see Figure 3) on the feed, gas production, and chromium dosage were as follows:

| | |
|---|---|
| Substrate fed (as acetic acid) .. | 8.307 gm. |
| Gas production (theoretical) ... | 6,197 ml. |
| Gas production (actual) ..... | 5,768 ml. |
| Gas return ..... | 93% |
| Total Cr added (as $CrCl_3$) .... | 276 p.p.m. |

The effect of hexavalent chromium on the rate of acetic acid fermentation by the methane bacteria was investigated using two anaerobic digesters. The usual period of stabilization was allowed before introduction of the

hexavalent chromium (as $K_2CrO_4$). The results obtained were as follows:

*Digester 1:*—The first dose of 5 p.p.m. hexavalent chromium (as $K_2CrO_4$) caused only a slight decrease in the daily rate of gas formation. On the third day after this dose was administered the fermentation responded normally to the acetic acid feed (0.2 gm. acetic acid). The second dose of 2.5 p.p.m. had no effect. During the next phase of the investigation small daily doses of chromium were added along with the normal daily acetic acid feed (0.2 gm.). Chromium concentrations of 1.25 p.p.m. for 6 days and 1.5 p.p.m. for 4 days did not alter the rate. However, when the daily dose was increased to 2 p.p.m. for 2 days and 2.5 p.p.m. for 1 day, a decrease in activity was noted. Reducing the next dose to 1 p.p.m. allowed fermentation to resume its normal activity. The quantitative data (see Figure 4) on feed, gas production, and chromium dosage were as follows:

| | |
|---|---|
| Substrate fed (as acetic acid) | 10.907 gm. |
| Gas production (theoretical) .. | 8,136 ml. |
| Gas production (actual) ..... | 7,471 ml. |
| Gas return ..... | 92% |
| Total Cr added (as $K_2CrO_4$) .. | 34.5 p.p.m. |

*Digester 5:*—An initial 2.5-p.p.m. dose of hexavalent chromium (as $K_2CrO_4$) had no effect on daily gas volume being produced by the fermentation from 0.2 gm. acetic acid per day. A dose of 17.5 p.p.m. added on the twenty-sixth day caused a temporary slump in the rate. Analysis of the fermentation liquor two days after the 17.5-p.p.m. dose showed that only 0.5 p.p.m. chromium remained in solution. After the fermentation recovered (approximately 6 days) it was given 2.5 p.p.m. daily for 5 days. At the end of this period a decrease in activity occurred. Decreasing the chromium loadings from 2.5 p.p.m. to 2 p.p.m. and then to 1.5 p.p.m. did not halt the downward trend. Chromium loadings were stopped entirely and normal operation was resumed after a waiting

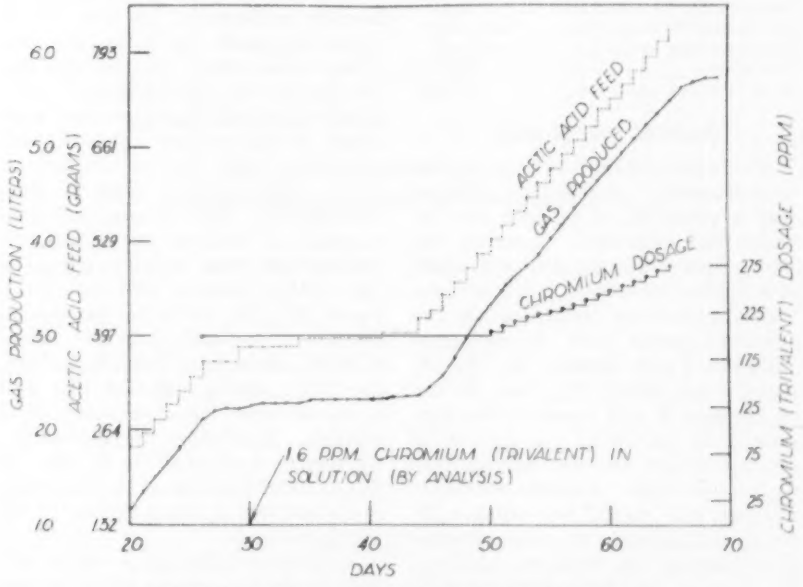


FIGURE 3.—Effect of trivalent chromium (Digester 3).

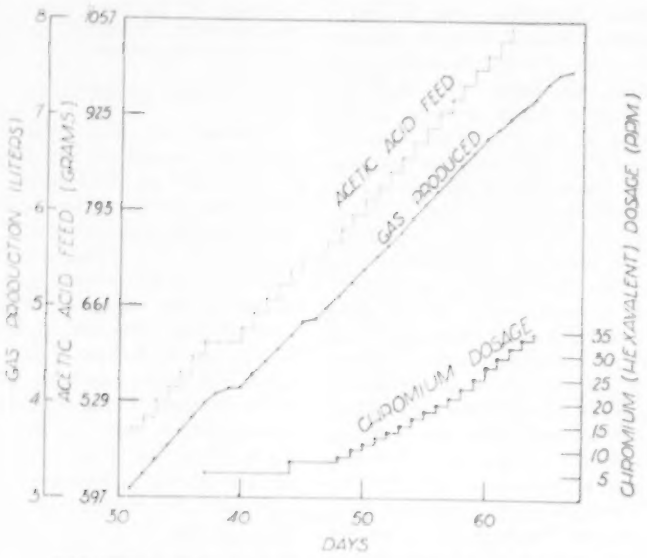


FIGURE 4.—Effect of hexavalent chromium (Digester 1).

period. The quantitative data (see Figure 5) were as follows:

| | |
|---|---|
| Substrate fed (as acetic acid) | 8,107 gm. |
| Gas production (theoretical) | 6,047 ml. |
| Gas production (actual) | 5,474 ml. |
| Gas return | 90% |
| Total Cr added (as $K_2CrO_4$) | 38 p.p.m. |

## Rate of Precipitation

The results obtained in these studies on 9 anaerobic fermentations indicated that a precipitation of both the trivalent and hexavalent chromium was taking place. The rapidity with which this removal of soluble chromium was taking place was studied using two stabilized acetic acid fermentations (Digester 7 and Digester E). To Digester 7 was added 200 p.p.m. Cr and to Digester E was added a 50-p.p.m. dose of Cr (as $CrCl_3$). A feed of 0.2 gm. acetic acid was also administered at the same time. Periodic chromium analyses were carried out within a 30-hr. period (Figure 6). Gas production following the chromium additions was normal in both fermentations. The chromium in solution decreased rapidly. The fermentation containing the higher initial chromium concentration showed a much greater rate of decrease in the first 3 hr. after the addition was made. In 12 hr. the chromium concentration in the two fermentations was approximately equal. Precipitation of chromium not only occurs in the actively operating fermentations, but also in the uninoculated basal medium used in these experiments. An average of four analyses of medium containing the uninoculated basal and 200 p.p.m. Cr (as $CrCl_3$) showed that only 11.2 p.p.m. trivalent chromium remains in solution at the end of 24 hr. When $K_2HPO_4$ was omitted from the medium, the 24-hr. analyses showed that 34.4 p.p.m. trivalent chromium remained in solution. In all cases, the medium was adjusted to a pH of 6.0 to 6.1 with 1N NaOH, after addition of the chromium compound and a single feeding of 0.2 gm. acetic acid.

A typical grayish-green sludge collects in the digesters to which the trivalent chromium has been added. The

chromium added to the fermentations was found to be in this sludge. The hexavalent chromium appears to adsorb on the asbestos mat in some form and then undergoes a slow reduction. This is indicated by the loss of yellow color from the fermentations fed the hexavalent chromium. The sludge becomes grayish green in due time.

Addition of $CrCl_3$ solutions to the fermentation was accompanied by increase in the H-ion concentration. A concentration of 200 p.p.m. Cr (as $CrCl_3$) was sufficient to lower the pH of the uninoculated basal medium one-half a pH (Table I).

**TABLE I.—Effect of Addition of $CrCl_3$ on the pH of the Basal Fermentation Medium**

| Cr. (p.p.m.) | pH |
|---|---|
| 0 | 6.25 |
| 100 | 5.98 |
| 200 | 5.75 |
| 300 | 5.65 |

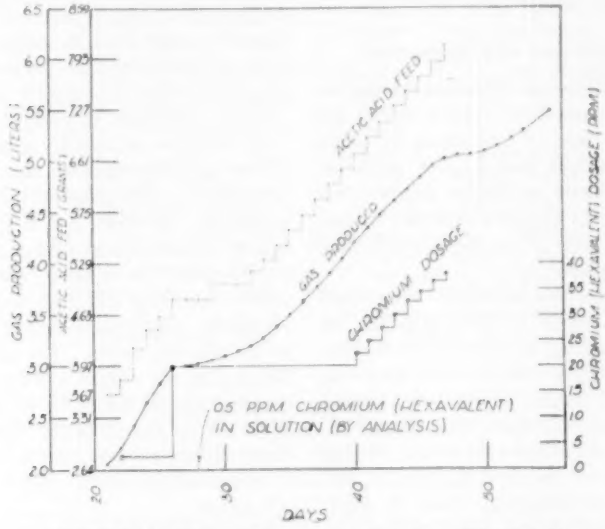


**FIGURE 5.—Effect of hexavalent chromium (Digester 5).**

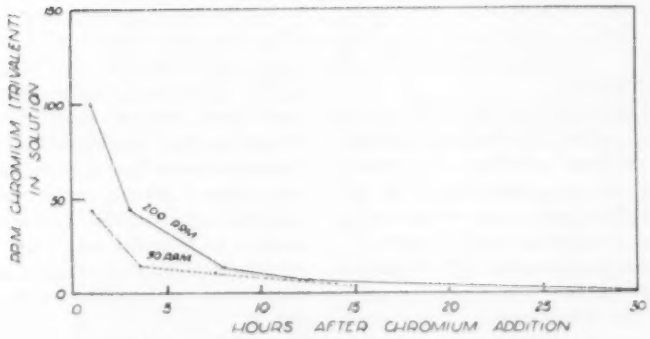


**FIGURE 6.—Rate of trivalent chromium precipitation.**

Removal of phosphate as the relatively insoluble $CrPO_4$ may occur, decreasing the buffer capacity of the medium. The precipitation of trivalent chromium was more complete in a 24-hr. period when $K_2HPO_4$ was present in the medium. In this connection, it should be mentioned that the normal stabilized fermentation being fed 0.2 gm. acetic acid has a pH of 6.8 to 6.9 before feeding and 6.1 to 6.2 after feeding. The pH value increases as the substrate is converted into carbon dioxide and methane.

## Discussion and Summary

The addition of trivalent chromium in daily doses of 3 to 6 p.p.m. did not affect the rate of conversion of acetic acid to carbon dioxide and methane. Concentrations at higher levels (that is, 10 p.p.m.) caused a decrease in fermentation rate after the seventh dose had been added.

Evidence was obtained that high doses of from 50 to 200 p.p.m. Cr (as $CrCl_3$) could not be followed by further daily additions, even in concentrations as low as 5 p.p.m., unless a rest period of sufficient duration was permitted. The optimum length of time for resting approximated the time required to stabilize the fermentation, about 25 days. Normal gasification returned in approximately 16 days when the substrate was kept at 0.2 gm. per daily feed. At this time the fermentations were sensitive to further additions of trivalent chromium in concentrations of 50 p.p.m. or greater.

Single doses of from 50 to 200 p.p.m. have been added to stabilized fermentations without altering appreciably their rate of gas production. The addition of 200 p.p.m. may produce rate decreases in certain cases (Figure 3).

Rapid precipitation of trivalent chromium takes place after its addition to the fermentations. However, the bacterial population receives the effect of the decreasing soluble chromium concentration over a period of some hours. For example, concentrations of 200 p.p.m. and 50 p.p.m. were reduced to about 10 p.p.m. in a 12-hr. period (Figure 6). The first dose of this magnitude can be tolerated, but subsequent doses tend to prolong the exposure of the bacteria to the toxic influence of soluble chromium.

The precipitated chromium, accumulated as a grayish-green sludge, did not impair the digestion process. Conversion of acetic acid to carbon dioxide and methane was high, even when 550 p.p.m. trivalent chromium was added (that is, digesters 10 and 12).

Hydrolysis of $CrCl_3$ increased the H-ion concentration of the fermentation liquor. The acetic acid feed also produced the same effect. The stabilized fermentations had a pH of 6.8 to 6.9 prior to feeding the 0.2 gm. acetic acid and pH 6.2 to 6.1 after. Normally, gasification returns the pH to its original value. The addition of 200 p.p.m. Cr causes a temporary decrease from pH 6.2 to 6.1 to pH 5.75 to 5.65. With precipitation the pH returns to its normal value, depending on the residual acetic acid in the fermentation.

The greater toxicity of the hexavalent chromium as compared with the trivalent (9) (10) has been confirmed in the methane fermentation of acetic acid. A daily dosage of 1.25 to 1.5 p.p.m. chromium (as $K_2CrO_4$) allowed normal digestion to take place. Concentrations higher than 1.5 p.p.m. caused decreases in the activity of the fermentations after 3 to 5 doses had been given. Normal rates were reestablished when a rest period was allowed. As was the case with the trivalent chromium, the hexavalent chromium was precipitated (Figures 4 and 5).

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## JOSEPH W. ELLMS DIES

Joseph W. Ellms, 82, recently retired Commissioner of Sewage Disposal, Cleveland, Ohio, and a well-known authority on water purification and sewage treatment, died February 7, 1950.

A graduate of Massachusetts Institute of Technology, Mr. Ellms was best known for his development of the rapid sand filtration of water and the hydraulic jump coagulant mixing flume. He also served as consultant on several of the large municipal water and sewage treatment installations of this country, in addition to serving as an expert witness in litigation involving sanitary engineering problems.

He was the author of numerous technical papers on the chemistry of water and on the problems of operation of water and sewage treatment plants, as well as the book "Water Purification." Among his many committee obligations in technical societies he was a member of the original Committee on Standard Methods of Water Analysis of the American Public Health Association in 1905.

G. E. Flower, formerly superintendent of the Cleveland Southerly sewage treatment plant, has been named to succeed Mr. Ellms as Commissioner of Sewage Disposal.

# Stream Pollution

## BACTERIAL STANDARDS FOR NATURAL WATERS*

By Abel Wolman

*Professor of Sanitary Engineering, The Johns Hopkins University, Baltimore, Md.*

It is difficult, if not impossible, to discuss any standards for engineering application or to formulate quantitative requirements therefor, without giving serious consideration to the whole philosophy of standardization in the sanitary engineering field. The questions which must be posed are:

1. Is quality an area in which standardization is either indicated or desirable?
2. If such standards are worthy of formulation and of application, what should they be?

A sharp distinction should be made between the standardization of methods for diagnostic application and the standardization of practices or concepts. In the first category, tools are required which possess both uniformity and interchangeability of technical language. In the second, the criterion of judgment is introduced and it must loom large in final decisions. When one attempts to standardize judgment, by developing convenient and often illogical devices as substitutes for reasoning, nothing but confusion is likely to result. It is recognized, of course, that for many workers in any field "handbook criteria" are invariably sought and equally invariably applied injudiciously. In the subject matter which this paper covers the desire for easy and convenient substitutes for thought and judgment, in the form of standards of quality, has reached a new high. Standardization for all features of natural waters has become one of the major sanitary engineering indoor sports.

Historically, ample support may be summoned for the thesis that standards of judgment are dangerous, fallacious, and inappropriate to scientific workers. These warnings range all the way from the sharp but cogent comment (1) of the late Professor Sedgwick, in describing standards of sanitation as "devices to save lazy minds the trouble of thinking," to equally significant but more refined warnings by Phelps, Whipple, Schroepfer (1), Velz (2), and Hedgepeth (3), to mention only a few through the last half century. Even the writer (4), at the annual convention of the Federation in October, 1940, reflected on the absence of any sound basis for universal standardization of desirable or desired characteristics of stream quality. Sedgwick's criticism is still valid that "standards are often the guess of one worker, easily seized upon, quoted and requoted, until they assume the semblance of authority."

### Reasons for Growth of Stream Standards

In the intervening decade, however, the search for and the introduction into law and regulation of stream criteria has proceeded at a fast pace. Part of

* Presented at 22nd Annual Meeting, Federation of Sewage Works Associations: Boston, Mass.; Oct. 17–20, 1949.

the process has been engendered by the literal intimidation of many workers in the field by the imaginative demands of certain militant organizations. In other instances, the appeal of the convenient handbook has been overwhelming. In still others, the subtle attractiveness of "zoning" has given the necessary fillip to this standardization technique. In this pursuit toward the quantitative millennium for qualitative matters of judgment a number of underlying philosophies have found their full play. At the one end of the spectrum are found the criteria established to preserve original quality and concomitantly, therefore, to avoid original sin. In this particular philosophy the studied and judicial comment of the late Professor Whipple that a regulatory edict, both in law and in philosophy, should establish the minimum for safety rather than the maximum of hope, is being ignored. The re-emphasis on this dictum was equally cogently and intelligently set forth by Frost and others, in sharpening the distinction between standard methods and so-called standards of judgments.

In the other extreme the philosophy has predominated that standards of quality of streams should be descriptive of the actualities and the realities of the local scene, a more justifiable basis of description than that already suggested.

In his paper some 10 years ago, the author (4) proposed certain tasks for the Federation. His arguments at that time, persuasive as they seemed to him, did not fall on fertile ground. The suggestions for Federation consideration, which revolved around the central problem of undue standardization of judgments, have yet to be fulfilled. In the interval new adherents to the cult of standards have entered the field. Some point with pride to the fact that virtually every state, either by statute or by administrative rule, has formulated criteria of quality. Many of them have given substantial scientific clothing to the criteria by introducing the concepts of zoning, to add additional difficulties to the administrator who is confronted with moving situations within a framework of restraint.

Paralleling these steps has come the unprecedented rise in the costs of sewage and industrial waste treatment. In 1942, reasonable per capita construction costs for sewage disposal were listed as from $3.00 to $12.00. Now that these costs have climbed 4- and 5-fold, it is again timely to remind the Federation and its members that stock-taking, both as to philosophy and as to quantitative translations of philosophy into action, is past due. At a recent Florida meeting of a professional group in the public health engineering field one of the speakers (5) warned that the public may get fed up before long with excessive costs for capital, maintenance, and operation investments in sewage treatment. His plea was, of course, for the introduction of imagination into this popular field of development rather than to the continuing adherence either to forms or to standards of applicability, which cannot be and in many instances should not be supported by corrective structures.

The hold which stream criteria have on both professional and lay workers in this field is sometimes astonishing. The slide rule and mathematical devices have begun to force out of consideration critical appraisals of stream pollution abatement decisions.

## Ohio River Report

When the Ohio River study was under way, the Supervisory Board, of which the writer was a member, went to extraordinary pains to avoid setting up criteria of stream quality in its major report tabulations. It spent hours in selecting language that would warn the reader that the tabulations were intended to be simple descriptions of characteristics of various sectors of the river. They were not in-

tended to zone, to delimit, or to restrict the stream in any or all of its portions by a special set of criteria. In spite of all of this care and what was thought to be a relatively happy choice of phrases, wherever one turns one is confronted with these descriptions of a stream adopted in law or regulation throughout the country as stream quality standards. The language in the Ohio River report (6) is worth repeating here: "In view of the variety, distribution, and extent of surface water uses, it is undesirable to establish rigid stream quality standards for general application in the Ohio River Basin, and the data in table 7 are not to be applied in that matter. The public interest can be served only by adapting standards to conditions existing in individual stream reaches, and by giving consideration to the most valuable stream use."

These Ohio River characteristics, designed entirely for purposes of study, have found their way into law and into regulations with sufficient modification to add both to their complexity and to the general confusion in their applicability. The revisions are often mere reflections of a desire for originality on the part of the person responsible for them.

## Standards vs. Judgment

What can one say about criteria of stream quality, solely from the standpoint of bacterial content, when one state alone offers five ways of avoiding original sin, depending on the economic status of the bather? And what can one say, furthermore, of the state of affairs in which, as was pointed out 10 years ago, one state insists that it is unsafe to swim in a body of fresh water which exceeds 5 coli per 100 ml. and an adjacent state insists with equal fervor that equal safety is afforded to the swimmer by a bacterial density of 500 times that amount? What can be said about a regulatory agency's desire when it establishes a standard of bacterial density that virtually rules out of use 95 per cent of the available surface streams within its territorial limits, provided, of course, it rains on occasions and the agricultural terrain is in part washed into the surface streams?

The most sedulous search of current literature discloses only one carefully controlled epidemiological survey (7) of this problem, yet the criteria which resulted from that study have been ignored in many of the states.

How valid is the reason frequently given for this drive that every municipality and every industry must know in black and white how a stream is zoned before its problem may be intelligently reviewed with a state regulatory agency? To the writer, at least, the validity of this argument for confounding judgment with precept holds very little water. Almost every situation on almost every body of water in this country is a problem in itself. As a rule, the solution to such problems is not assisted materially by referring to a convenient handbook. The solution lies in most instances in the considered balancing of technical and financial conveniences and equities, out of which the perennial compromises of judgments ensue. In more instances than one, any criterion, in law or in rule, which stands in the way of these compromises is unfortunate. They lead either to unwise and unwarranted expenditures or to acrimonious debate and delay in correctives. Administrative judgment and decision are the results of intelligent diagnostic techniques, bargaining, availability of the dollar, and adaptability to the local scene. They are not and never have been the result of legislative fiat, even when this is re-enforced by formulas of pseudo-mathematical character.

Members of the Federation have their major interest in the underlying philosophy, perhaps rather than in the quantitative explorations thereunder.

At first sight the latter dominates most of the literature. Beneath the surface, however, in administrative practice the qualitative applications as a rule will determine the success or failure of the pollution abatement programs. Where this is not the case and the rule is both formalized and applied, there is a reasonable expectancy, based on past experience, that the public is being forced to pay more than it should for the desired result. This practice is doomed to failure when the public begins to understand the way in which the criteria were born and how they are being applied.

### Ultraconservative Safety Factors

One is pushed to discover or to enunciate even a general principle in stream quality which can be guaranteed to be applicable without modifications to every scene in the United States. Someone has said that "no generalization is true," even including that one.

This problem of safety as applied to bacterial standards in waters is not peculiar to sanitary engineering practice and discussion. Its epidemiological bases are unfortunately extremely limited. They are so limited that Stevenson and Woolsey, of the Public Health Service, have undertaken a thoroughgoing study, long overdue, of the relationship between natural bathing water quality and the occurrence of illness attributable to bathing in natural waters. Even when the results of their study are available the very nature of the case would predispose the careful student to adopt rigid criteria with a maximum of caution in the administrative field.

The search for objective criteria of safety in fields much more susceptible to answers has gone on for many years, as in the problems of structural design. Freudenthal (8) has recently said: "The concept of safety is probably the most important—and certainly the most controversial and vaguely defined concept in structural design. Safety factors varying between 1.25 and 10 are found in current design specifications for different materials and structural parts. These values were chosen arbitrarily on the basis of subjective judgment." If this is true in structural design, in which the evidence for behavior is greater in amount and in laboratory and field experience, how much truer is it in the field of bacterial standards where the peculiar history and characteristics of the phenomena are extremely limited and complex?

### Wide Range of Permissible Limits

This paper might elaborate on the assumptions now underlying the various standards established for fresh and sea water over the last few years. To this author at least, that type of record is quite pointless, particularly in view of the fact that in 1942 such a review was carefully and elaborately made by Schroepfer (1) and in 1948 equally carefully and elaborately canvassed and extended by the Joint Committee of the Conference of State Sanitary Engineers and of the Engineering Section of the American Public Health Association. Both documents disclose a wide variation in the different states in the range of permissible limits, virtually all of them relatively unsupported by anything but precedent, imagination, ingenuity, enthusiasm, and nostalgia. The author finds himself in the same predicament as the aforesaid Committee in attempting to cull from this spectrum of criteria a conclusion which would stand the scrutiny of an objective judge.

The Joint Committee makes the best of a confused situation in the following judicious language in several of its conclusions:

> "There is still a wide divergence of opinion as to the standards of acceptable bacteriological quality for outdoor bathing places in streams, rivers, lakes, and tidal waters, although there is apparently some crystallization of thought on the subject.

"Early attempts to set a limiting bacteriological standard equivalent to 120 coliform organisms per 100 ml. (50 coliform organisms per 100 ml. according to Phelps' index) have been largely discarded. Such values are usually attainable only in lakes and excellent quality tidal waters. Streams subject to no pollution other than animal contamination may often show a coliform index of 240 to 1,000 per 100 ml., with occasional samples showing still higher indices. In West Virginia, the State Water Commission describes a Class A water as a good source of recreational water where the average coliform index of samples each month does not exceed 1,000 per 100 ml.

"In the summer of 1948 the New York City Board of Health adopted a declaration of policy for the guidance of the Department of Health in classifying bathing beaches. The action of the Board does not affect that section of the Sanitary Code which prohibits the operation of bathing establishments in certain specified areas. The classification adopted is as follows:

*Class A: Approved Beach Waters*

Group 1. Safe Waters

(a) Epidemiological experience satisfactory, and

(b) Sanitary survey satisfactory, and

(c) Coliform average not in excess of 1,000.

Group 2. Approved, but subject to reclassification in light of continuing observation.

(a) Epidemiological experience satisfactory;

(b) Sanitary survey satisfactory, but beach waters exposed to increasing pollution; or

(c) Coliform average above 1,000, but not in excess of 2,400.

*Class B: Polluted Beach Waters Not Recommended for Bathing*

(a) Epidemiological experience satisfactory;

(b) Sanitary survey discloses sewage material on beach or in water immediately adjacent to beach; and

(c) Coliform average above 2,400, with 50 per cent of samples in average above 2,400.

*Class C: Unsafe Beach Waters*

(a) Epidemiological experience discloses evidence of infection incident to beach bathing;

(b) and (c) Not necessarily relevant in light of (a) above.

"In connection with this system of classification, the Commissioner of Health will issue warning to the public and the proprietor of the beach that the waters of that bathing beach are polluted and not recommended for bathing when a beach falls in the Class B designation; when a beach falls in the Class C designation, warning to the public and the proprietor will be given by the Commissioner of Health and he shall, within 24 hours, call a special meeting of the Board of Health for the consideration of such other measures as appear necessary for the protection of the public health. This classification is reported to be based on epidemiological experience, bacteriological findings and sanitary surveys, and is influenced by the unique conditions found in the harbor waters of New York City."

The Joint Committee went on to say:

"It is emphasized that final classification of bathing waters should depend largely upon sanitary survey information. Bacteriological analysis findings should be used as a guide. Some areas of the country are reported to be able to meet bacterial standards for natural surface waters with minimum limits of coliform indices (as used herein) of not more than 240 to 500 per 100 ml. Such excellent quality is, of course, greatly to be desired. However, experience indicates that other sections of the country, especially those located in more densely populated areas and among cultivated lands, cannot maintain such conditions.

"Waters showing a concentration of most probable numbers of coliform organisms of less than 1,000 per 100 ml. are considered in most such areas to be fairly acceptable for bathing unless the sanitary survey discloses immediate dangers from human sewage pollution; however, it must be admitted that bathing beaches where the content of coliform organisms runs as high as 2,400 per 100 ml. on the basis of most probable numbers, or sometimes even higher, have been used without reported evidence of illness, and this limit of 2,400 per 100 ml. is still employed as a criterion of acceptability in some states. The trend is, of course, to reduce bacteria counts where possible by sewage treatment if human sewage is a threat, and the attainment of reasonable progress in this direction is to be hoped for. While bathing areas should

always be free of visible forms of sewage matter that might contain pathogenic organisms, serious pollution may be present in many waters where treatment of sewage removes visible evidence of sewage solids but does not eliminate dangerous concentrations of bacteria."

### Validity of Limits Questionable

These statements selected from the Joint Committee's report offer about as reasonable a description of the present state of affairs as the author has been able to find, leaving the central question open for further discussion as to whether the final suggested limits have any validity. The Federation should stimulate discussion by its members as to whether or not standards should be developed which are acknowledged to be without scientific foundation, even though as in these cases, the weight of authority is heavily placed on the continuation of their use.

Little or nothing has been said about the bacterial standards, particularly in fresh waters, where such waters are to be used as sources of potable water. This omission has been deliberate, simply because the issues are not as controversial or of such practical significance as they are in respect to standards of quality for recreation. One of the primary reasons for this view lies in the fact that wide areas of operating possibility are provided in the raw water bacterial standards, as applied to water works intakes. Until very high concentrations are reached (in excess of 10,000 per 100 ml.) the well designed modern water treatment plant handles normal and shock loads of bacteria with both economy and practicability. In other words, regulatory agencies have found it unnecessary to establish rigid limits for these purposes at the same time that they have been constrained to develop far more rigid limitations in bathing waters, where the evidence for such action is much less convincing. It is only in special instances that some administrators have moved toward heavy expenditures in sewage treatment to relieve the bacterial load on water plants, even though the costs of accomplishing the same purpose via water treatment are generally materially lower than by sewage treatment.

### Application to Salt Waters

A word should also be added with respect to the situation in sea water of various salinities. The evidence is accumulating that in salt water, varying from as low as 4,000 to as high as 40,000 p.p.m. of chlorides, coliform organisms tend to decline more rapidly than would be accounted for by strictly dilution calculations. Whether these effects are primarily due to saline content or not still remains to be demonstrated. The findings by Zobell, Anderson, and Smith (9) in the Great Salt Lake in Northern Utah, by Ketchum *et al.* (10) in the salt water areas of New England, by Wolman (11) in Puget Sound and by Tyler and Seabrook (12) in Commencement Bay (Puget Sound in the vicinity of Tacoma) all disclose, however, that the mortality of the coliforms and associated bacterial groups is undoubtedly greater than dilution alone would provide. These reductions are reflections of the whole unfavorable environment to be found in such saline waters. By and large, the index organism does not appear to survive under the conditions provided by many salt water areas, in spite of the fact that some limited studies disclose that some pathogens, as in fresh water, may survive for extended periods in small numbers.

All of the restraints in the application of standards to fresh water should, therefore, be critically observed when they are applied in salt water areas. The same absence of epidemiological warrant and the same consideration of economic balances must control any judgment decision on the permissible

bacterial concentrations in salt waters. It is extremely doubtful whether efforts to restrict the uses of these waters for recreational purposes, where concentrations of coli are in excess of hundreds per 100 ml., with resultant unwarranted expenditures of public monies, will bring any measurable parallel return in public health or safety.

## Conclusions

All of these discussions lead to the suggestion that the Federation should pursue the following important objectives:

1. To participate officially with other voluntary associations in discussions of the general validity of judgment standards.

2. To participate with both voluntary and official agencies in the discussions of judgment standards which such agencies perpetuate.

3. To evaluate in selected areas of the United States the results of sewage treatment plant installations, with particular respect to the bacterial accomplishments originally anticipated.

4. To appraise realistically the practicability of actually using the wide variety of stream bacterial standards which have already been translated either into law or into administrative rule.

These proposals are made under the assumption that the Federation, interested as it must be in sewage and industrial waste treatment, should begin to shed light officially on the validity of the criteria which should guide the designer, the operator, and the regulatory agency. The late Max Planck (13) succinctly establishes the basis for such hopes in the following terms: "But even the keenest logic and the most exact mathematical calculation cannot produce a single fruitful result in the absence of a premise of unerring accuracy."

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## DISCUSSION

By Albert H. Stevenson

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Professor Wolman, in expert style, has raised interest arousing questions. He has considered the socio-economic impact on the community of the use by the sanitary engineering profession of the so-called "judgment standards" with relation to the bacterial quality of natural waters. It is always a challenge to hear Professor Wolman's philosophy on this subject.

Perhaps the word "standard" is a misnomer. It indicates a certain inflexibility, which is unsatisfactory where matters involving the interplay between biological and engineering factors are concerned. The term "guide" might be a more suitable term. Certainly the legal adoption of "standards" or "guides" emphasizes the inflexibility and is most undesirable. However, the complete disregard of standards or guides is equally undesirable from an administrative standpoint. I speak now of the state and local health officer or water pollution control official who is faced daily with the problem of answering the question: "Is this or that particular natural water safe for a particular use from a public health standpoint?"

Perhaps at this point a distinction should be made between uses involving intimate and direct contact between man and natural waters, or their living inhabitants, and those in which there is opportunity for control of the quality of waters prior to their contact with man. As Professor Wolman mentioned, the establishment of standards for these latter uses (such as for natural waters that are to be used for potable purposes) generally has been given only limited consideration by health officials. The reason for this is apparent through control of water quality by treatment processes prior to its reaching the consumer. In this instance, suitable guides for judgment were developed in comprehensive studies by H. W. Streeter (1), based on waterworks treatment practice at that time.

There are wide variations and major weaknesses in existing bacterial standards for natural recreational waters with respect to the epidemiological basis on which they are established, as was pointed out by the writer in an earlier paper (2). Professor Wolman has ably emphasized these deficiencies. It is for this reason that the Public Health Service does not recommend a bacterial standard for natural bathing waters. Rather than avoid the use of standards or guides completely, however, it would be more advantageous to secure adequate technical data on which to base them and to revise the limits of those in existence to conform to epidemiological and technical findings.

### Research in Progress

In an attempt to obtain such scientific data, the Environmental Health Center of the Public Health Service has two programs underway which relate directly to the question of bacterial standards for natural waters. These programs cover two different uses of waters where the contact between man and the water, or its living products, is direct and without intervening bactericidal treatment.

First, a series of studies of natural waters has been undertaken in an attempt to correlate water quality with the illness incidence found among population groups which use the waters for bathing or swimming. The first study was made in the Chicago area as a part of the Tri-State Survey

of Lake Michigan Waters (3) in the summer of 1948. In this special study, data on the water qualities of two bathing areas in Lake Michigan were obtained, together with a daily record of the swimming and illness experience of some 5,000 persons living adjacent to the two bathing areas during a 70-day period. In September, 1949, field work on a similar study was completed in two Kentucky communities, Dayton and Bellevue, where many of the residents use the Ohio River opposite Cincinnati as a bathing area. It is proposed to make additional studies in other geographical areas, using bathing waters of different chemical composition and of different bacterial quality.

At the initiation of this program, it was realized that no conclusive evidence leading to the development of a sound bathing water standard or guide of general applicability could be obtained until an entire series of such studies was made. Obviously, any one, two, or three studies alone would merely reflect the conditions in the local area under consideration, as Professor Wolman mentioned previously. However, when a larger series of studies has been made, it is believed that conclusions of a broader nature can be drawn. In these studies, it is realized that there may be no sharp line of bacterial quality above which bathers may be expected to become ill and below which they will not. However, from the studies being conducted, it is expected that definite information will be obtained to show that bacterial contamination above certain levels may be expected to cause an unwarranted amount of illness. In the fringe area below these levels there will always be a place for judgment, taking into consideration public demand for water, economic factors, proximity and significance of sources of pollution, and other phenomena. However, when these levels can be established on a sound epidemiological basis, they will furnish administrators of control programs with a very useful guide to action and a discretionary tool that may save expensive comprehensive surveys to support their position.

The second program undertaken by the Environmental Health Center is concerned with the problem of shellfish sanitation with particular reference to the quality of coastal waters used as growing areas, involving as it does the human consumption of raw or partially cooked shellfish. Inasmuch as laboratory studies must necessarily precede field investigations, bacteriologists are currently conducting research on this problem at the Environmental Health Center laboratory at the Woods Hole (Mass.) Oceanographic Institution. When the necessary techniques and basic data are secured, they will be used on comprehensive studies of coastal growing waters.

Although sanitary engineers generally think solely in terms of coliform bacteria when talking about the bacterial quality of natural waters, their viewpoint could be broadened on this subject. Other bacterial indicator organisms, as well as other survey techniques, are needed to supplement the information obtained through the use of the coliform group as the sole indicator organism. In the studies conducted in the Chicago and Cincinnati areas on bathing water quality and in the studies of shellfish and shellfish growing waters at Woods Hole, there is being used, in addition to the coliform group, the enterococcus group of organisms, which are fecal streptococci associated with the intestinal tract of man and animal. After nearly two years' intensive study of these organisms in the Cincinnati laboratories and in the field, the bacteriologists feel that there is definite promise that the enterococcus group, although a coarser measure of pollution than the coliform group, will provide information on "recent pollution," which we have been unable to secure with the coliform test.

In summation, it is desired to emphasize two points:

1. Standards, or preferably guides, on bacterial limits of quality for natural waters used in intimate contact by the public, fill a most important need, from an administrative standpoint, of the public health and water pollution control official.

2. These guides may be worthless unless they are based on sound scientific principles, and unless the fringe area below the minimum bacterial quality levels established is applied with judgment to the local situation under consideration.

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## MORE STATES TACKLE STREAM POLLUTION

Legislatures of at least 8 states took some action in 1949 to tighten anti-pollution laws or to step up enforcement of existing sanitation laws, according to the American Public Works Association. Others set up commissions to study pollution problems.

In Wisconsin, a 5-man committee on pollution was set up by the 1949 legislature for the purpose of stimulating cities to build sewage treatment plants. In Tennessee, a long-range program for control of pollution in the state's streams will be submitted to the governor during 1950. It is being developed in accordance with action of the legislature in establishing a state stream pollution study commission.

Engineers of the Michigan Water Resources Board and the Health Department have set up a program for controlling the stream pollution in the Detroit metropolitan region, estimated to cost $100,000,000. Inability of cities in the area to finance sewage disposal plants has created serious pollution problems. Pollution controls by the state were strengthened by last year's legislature.

In a report of accomplishments for the past three years of Florida's stream pollution abatement program, the State Board of Health lists 108 waste disposal projects approved in the past 3 years, of which 77 have either been constructed or are under construction. The report also lists completion of 23 small industrial waste treatment plants and 35 small sewage disposal installations for areas where municipal sewage disposal is not available. Major surveys are in progress on pollution of streams by the phosphate, pulp and paper, and citrus industries.

In other legislative action concerning pollution control last year: A broad anti-pollution program was outlined in Arkansas and New Hampshire; Delaware created a new water pollution commission as part of a program of pollution abatement; and Illinois strengthened its Sanitary Water Board law. Legislation in line with provisions of the Ohio River Valley Water Sanitation Compact was passed in Ohio and Indiana. Iowa and South Dakota also strengthened their water resources agencies and provided for stricter control over pollution.

# THE OPERATOR'S CORNER

CONDUCTED BY HERBERT P. ORLAND

## YOUR LOCAL PAPER CAN HELP

The important problem of presenting to your voters vital factual information about your sewer system and treatment plant in many cases can be solved by a good heart-to-heart talk with the editor of your local paper. Any editor worth the name will be more than interested in presenting such material to his readers. It's good copy, not only from the news standpoint, but also for a feature article and as the subject of editorial comment. The last point is particularly true if anything of a controversial nature is involved—and there usually is. A series of articles in the local paper, presented properly, will acquaint the public with your situation first hand.

When the public really understands the facts concerning your system and plant, the groundwork has been laid for getting a program underway, presenting a schedule of increased rates, obtaining better equipment, or obtaining funds for improvements and better operation. Better public relations will result in better service to your town and will give you personal satisfaction in doing a more efficient job.

Who should prepare the material? Sewage works men usually are not public relations experts. However, a good reporter from the local paper can dig up some human interest facts about your sewage collection system and treatment plant, their good points and their weak ones. Of course, he'll need help from operating and management personnel in collecting pertinent facts and figures, and maybe even an anecdote or two. He'll want considerable background information. In general, however, leave the approach "angle" to the reporter and the editor, contenting yourself with the role of advisory "expert"—on sewage matters, that is.

Several plants have made the front page—not because of catastrophe or impending political scrapping, but in their own right as interesting municipal housekeeping functions that the public should know about. Several others have been the subject of full-page pictorial feature presentations; a few have made the rotogravure pages or have had 2-page "spreads" devoted to them. In almost every case the results have been renewed public interest in the sanitary arrangements of the community and better understanding of the major problems involved. In many instances, the publicity afforded has been the turning point in a bond election or a referendum item on legislation affecting the plant.

Have you a public relations problem? Seek expert advice. Generally, it's readily available, simply for the effort of talking to your local editor. Seeking his services need place you under no obligation, as he's helping himself when he helps you.

H. P. O.

# TO LIME OR NOT TO LIME*

*Chairman Leroy W. Van Kleeck, Principal Sanitary Engineer, State Department of Health, Hartford, Conn.:* The subject under discussion is the controversial one of liming of digesters and Imhoff tanks. One of the speakers, Mr. Schlenz, perhaps started us thinking along the lines of whether liming is needed or not in his historical statement of 1947 when he said that lime in any form or any amount had no place in a digester. A somewhat different viewpoint will be advanced by our first speaker, who believes in liming under certain conditions.

*J. H. L. Giles, Senior Sanitary Engineer, State Department of Health, Hartford, Conn.:* To lime or not to lime is a matter for each operator to decide on the basis of experience with his individual plant. In Connecticut, it has been the experience of many operators and representatives of the State Health Department that it is beneficial to add a few pounds of lime to the liquid content of a digester when it is being started up, in order to reduce an initial septicity which frequently develops in a tank during the first few weeks, whether it is heated or not.

It has generally been the experience of operators in Connecticut that for a heated tank of adequate capacity, no lime is needed after this first period of 3 or 4 weeks. A stabilized pH of 6.8 to 7.0 usually results in a digester kept at a temperature of 90° F., if it is of adequate capacity.

There are many sewage treatment plants in Connecticut that have had experiences which upon investigation and experimentation have resulted in the conclusion that periodic small additions of lime are necessary to get adequate digestion or to keep under control slow activities during the colder months for an unheated tank. We have also had two or three plants that have found it necessary to continue liming the year around in order to avoid the development of excessive accumulations of scum in unheated digesters.

The principal advice I would offer the operator is that no segregation of lime should be permitted in the bottom of the tank. Circulation of the bottom sludge with the incoming raw sludge is frequently helpful in avoiding segregation and permits regular testing of the pH or alkalinity of the digestion compartment. Overliming in one heated digester resulted in complete stoppage of digestion. On the other hand, the complete lack of lime in some tanks has resulted in very slow digestive action and frequently has resulted in excessive scum, septic conditions, and very poor supernatant.

Experience has indicated that in unheated separate sludge digestion tanks 50 lb. of lime per 1,000 population per week, added in small frequent doses, is not excessive, although at times even this amount is stopped for a period of two or three months during the winter in order to avoid foaming with the advent of warm weather. Generally, alkalinity below 1,000 and pH below 6 indicates the need for liming, whereas pH above 6.5 and alkalinity above 1,800 indicate that liming should be avoided, except as a very occasional application to stimulate action in the digester, which results in increased methane production.

*Harry E. Schlenz, Vice-President, Pacific Flush Tank Co., Chicago, Ill.:* When the statement was made in January of 1944 that "lime in any form or amount has no place in a digester"

* From transcript of 1949 Operators' Forum, 22nd Annual Meeting, Federation of Sewage Works Associations; Boston, Mass.; October 17–20, 1949. [One of six subjects discussed; discussions of other subjects have been published in THIS JOURNAL (Feb., 1950, p. 245) or will appear in succeeding issues. —Ed.]

it was realized that this thought was contrary to the general opinion of others on the subject. In fact it was so contrary to my previous thoughts on the control of sludge digestion that it took a great deal of evidence obtained the difficult way to give rise to a statement that lime could do more harm than good in a digestion system.

In a pamphlet on the control of sludge digestion issued to operators in 1941 I was so firmly convinced of the importance of liming that the statement was included: "pH should be checked at regular intervals, and lime should be added, if necessary, to keep the pH from dropping below 6.8." I had held such thoughts since leaving the University of Illinois in 1927 after being well indoctrinated with the knowledge of the importance of pH in the control of sludge digestion, and that the mystical value of pH 7 was the guiding control, and lime should be added until that value was maintained.

Time will not permit reference in detail to the mass of data available to support this radical view on the subject, but a few operating experiences will serve to illustrate the reason for present views against liming as a control measure.

In 1942–43 we were asked to attempt correction of a serious situation at one of the large naval training centers, where for 10½ months raw solids had been added to a digester system without any resultant digestion. During that period, about 9 tons of lime had been added to one of two 65-ft. diameter digesters, with the pH being raised from 5.0 to only 5.4. An inventory of the tank contents revealed that the upper ⅔ had a pH of 5.0 and the lower ⅓ a pH of 7.0, but the tank was dormant.

Still of the opinion that the liming procedure was not entirely wrong, it was felt that an excess of lime had been added. The first procedure, therefore, was to draw off as much of the bottom material as could be conveniently disposed of. A careful check of the operating records showed that the temperature had been maintained at the optimum of 90° to 100° F. during the last 2½ months of the 10½-month period so that except for the low pH proper conditions for effective digestion appeared to be present.

A continuous and large-volume recirculation of the tank contents was started, although this recirculation was restricted to the upper half of the tank. In 10 or 15 days, gas production started and the tank started to foam, at which time the gas production reached a peak of 4 to 5 times a normally anticipated rate.

It was found, however, that recirculation of material from the bottom of the tank to the top stopped gas production almost immediately and that the foaming action also was retarded. This indicated that recirculation of the sludge still containing some lime would show a retarding action on the rate of digestion.

The next example of the effect of lime was brought out in connection with the digestion tank installation handling solids from a malt house waste at Jefferson Junction, Wis. Because of the type of waste, the two digesters in the system were started very carefully, with the tank contents heated to an optimum point. The raw solids were then added, starting with a light load and increasing to the maximum load. The pH of the tank contents was initially 7.0, but in 10 days the pH had dropped to 6.56. Despite the experience on the project previously reported, it was decided to keep the pH at 7.0 and lime was added carefully, using approximately 100 lb. per day with a day of rest between subsequent additions. The 100 lb. of lime represented approximately 600 p.p.m. of actual lime. In seven days, with about 3,500 p.p.m. of lime having been added, the pH had risen but slightly to 6.6.

Due to the slight rise in pH as contrasted to the fairly large quantity of lime added, it was decided that no further additions of lime should be made. In another 7 days, with careful recirculation of the upper portion of the primary digestion tank in the two-tank system, gas production had started and was steadily increasing. However, it was again noted that with recirculation from the bottom of the tank gas production was sharply reduced. It should be noted that the lime accumulation in the tank had not been removed. During the next month the rate of digestion, with recirculation of the upper portion of the tank only, indicated that digestion was well established, with the tank taking the full raw solids load.

About that time a visitor to the plant who saw the records indicating that the pH of the tank contents was fairly low, insisted that the operator correct this condition by adding lime. The operator disregarded previous instructions and added lime, although the records do not show the quantity added. The result was immediate cessation of digestion in that tank. It was impossible to start the digestion again, with the result that all feed to the primary digester was stopped and the raw solids were diverted into the tank used for secondary digestion, which had never been contaminated with lime additions. To this day the secondary digester as shown on the plans is being used as a primary digester, the original primary digester being finally brought back into action without the use of lime.

A number of other examples and operating records could be mentioned if time permitted, but some reference should be made to the digestion installation at Crystal Lake, Ill., handling a yeast plant waste. This plant was designed and operated with only an allowance of 3 to 4 days for the full two-stage digestion. When the operating schedules were set up, instructions were given to omit the practice of taking pH readings. This digester system has been in successful operation since 1945 and there has never been a pH reading taken on the digester contents; thus, there has never been any occasion for the operator to add lime to correct for a low pH.

In conclusion, it might be suggested that it does not appear possible to establish good digestion conditions merely by correcting the pH of the tank contents. Instead, the pH is the result of having established good digestion conditions. It is much more important to start the digestion by providing an optimum temperature of the tank contents from the day that the first raw solids are added, and start adding raw solids at a rate that will prevent the building up of acid conditions, increasing the rate of raw solids addition as the tank is able to assimilate the load.

*W. W. Matthews, Superintendent, Gary (Ind.) Sanitary District:* It appears that Mr. Schlenz takes the stand that lime is not used simply because it has been brought in by the truckload and dumped indiscriminately into a tank. Each case requires careful thought. I have thought that operators, except perhaps the very newest ones, were sufficiently informed that they didn't think it necessary to try to control pH with lime.

If I were asked the average pH of our five digesters right now, I couldn't tell. The transfers are sampled each day and the pH is recorded in the laboratory book, but unless something is obviously wrong nobody pays any attention to them, because it is well known that at different plants digesters stabilize at different pH values.

As I remember, the digesters at Decatur, Ill., stabilize at about 6.5. I know ours are somewhere between 6.9 and 7.1. I have never tried to control pH or foaming with lime—let it run over the bank if it will, if it doesn't

bother your plant site—it will correct itself.

We use lime for a different purpose—to increase gas production. How that is accomplished I frankly don't know. We are troubled with oil. We get soluble cutting oils from one plant and the effect of such oils is insidious. We can't tell exactly when the soluble oil is coming in, and it builds up in the digesters. My theory on it is this: We know that oil will inhibit digestion; and when a tank falls out of line in gas production, where the total averages 35,000 to 40,000 cu. ft. per day for the five tanks, the outside operators notice it when they take their reading. Whenever everything else is normal as regards the sludge pumpage—no storms or anything unusual occurring—the corrective measure is to put 100 lb. of lime into a digester holding 1,300,000 gal. of sludge mixture. The chemical effect of that much lime on over 8,000,000 lb. of mixture is negligible.

It is thought that the action is a physical one, merely absorbing some of the oil and stimulating digestion in the tank. This follows from the observation that one of the best ways of drying up a lot of oil spilled on a concrete floor is to sprinkle it with lime.

I agree, however, that use of excess lime is definitely bad; it is like any other medicine and should be used as the doctor prescribes.

*Mr. Schlenz:* I do not feel that Gary has any real digester problems with its large digestion capacity (8 cu. ft. per capita). My thinking is directed toward those plants having less than 1 cu. ft. per capita.

Probably the lime added to the Gary digesters combines with the $CO_2$ in the gas to form $CaCO_3$ which soaks up some of the oil. However, the addition of 100 lb. of lime to 8,000,000 lb. of tank contents can hardly be considered liming. In the case I mentioned, the 100-lb. additions of lime were made to a 15-ft. digester, without changing the pH.

*Mr. Giles:* The description of recirculation from the bottom half of a digester indicates obvious over-liming of the tank. We had the same experience in an industrial waste treatment plant with three digesters. After the plant had been in operation a year there was no solid in the tank, only scum. The plant was handling a wool fibre waste with a 600-g.c.d. flow (5 m.g.d. for 8,000 population) and with absolutely no digestion.

We added, finally, a whole ton of lime to that small digester in 100-lb. batches. By that time the pH of the whole tank was over 8.4 and digestion had ceased. The scum went to the bottom, and it was thought that possibly, even though the digestion had been killed, some good had been done. Then came the stench; I have never seen or smelled anything quite so septic. A little more sludge was added and almost overnight the tank contents turned upside-down; all the dead sludge came to the top, and nothing we tried did any good. To this day it is impossible to control it; the scum is just broken up and taken off.

At one institution with a population of 1,000, an Imhoff tank was started up very carefully, with good digestion resulting. When some new buildings were built clay soil got into the sewer through the new connections. This practically solidified that whole tank. Intensive recirculation was necessary to work the clay out. After the tank was operating again, 20 to 25 lb. of lime have been very carefully added at a time, and recirculated so there would be no accumulation of lime. The tank has worked pretty well.

Two or three years ago the plant was enlarged, including a second Imhoff tank having 50 per cent more sludge capacity than the original one. The new tank was not limed for 1½ years, but we still didn't get what I con-

sider good digestion. There was very little action. When a new operator came to the plant, he had been accustomed to liming and the other tank was being limed, so he added lime—a total of 400 lb. in two months. The lime was added because the sludge was rather bad, but when 1½ ft. was drawn onto the drying bed, it was in good condition.

The general experience has been that a little liming, well applied, can help.

*E. A. Locke, Operator, Sewage Treatment Plant, Hartford, Conn.:* At Hartford, the plant is shut down for two months in the spring due to the high level of the river. There are 4 digesters, which contain a lot of well-digested sludge when the plant is opened up. Also, we probably have to take up about the full load of raw sludge.

It was found that raw sludge pumping lowered the pH. It was allowed to drop to about 6.8 or thereabouts before 100 lb. of lime was added. As the pH continued to drop to 6.6 it was thought that something had to be done, so a dozen bags of lime were added in each tank. This not only raised the pH, but also increased gas production. A little lime was added each day until the pH was around 6.8 or 6.9 and gas production was nearly normal. Judicious liming is now our standard practice in starting up again after a shut-down. Once the proper pH is attained liming is stopped.

*Mr. Schlenz:* It is possible that if Mr. Locke had just left the digester alone, the digestion would have come back. To support this contention I might refer to additional operating records for the Jefferson Junction, Wis., plant previously referred to. About 9 months after a good digestion action had been obtained in the digester originally designated as a secondary and which had been pressed into service as the primary tank to receive raw solids, there was a period of about 6 days when the pH had dropped off from the normal 7.2 to 6.3. The operating records indicate that there had not been any change in the operating procedures, no lime had been added, the temperature had been kept at an optimum value, and recirculation of the upper portion of the tank contents had been practiced in the usual manner. Without any special changes in operation, after a further 10-day period the pH returned to a normal of 7.0, but the gas production increased to about three times the normal anticipated rate. It appears that something in the digester action caused raw solids to be stored up, with a resultant reduction in the pH, but that without any special manipulation on the part of the operator the digestion started again and went beyond a normal rate.

*L. J. Fontenelli, Supervising Engineer, Rahway Valley (N. J.) Joint Meeting:* I'd like to ask Mr. Schlenz if, during the period when the pH dropped rapidly, loading of fresh solids was continued.

*Mr. Schlenz:* According to the records, solids were being added at that particular time and were actually 20 to 25 per cent more than the normal loading for the preceding period, and continued at the high value from that period throughout the balance of the recorded data.

Possibly due to the increase in the rate of raw feed, the digester had to adjust itself to the change. The volatile acids increased to a high value with the heavier load, but for some reason or other the tank adjusted itself properly to that heavier load. As the heavy load went in the volatile acids went up and the pH went down. Then the tank gradually adjusted itself, without adding anything other than the raw solids.

*M. M. Gibbons, Superintendent, Board of Water Commissioners, Rahway, N. J.:* If a plant is operating 24

hr. per day on a fixed digestion tank capacity, it is very nice to say, theoretically, that the digesters should be rested. However, something must be done with the fresh solids. Rahway, of course, is confronted with lack of digestion capacity, so that it is imperative to keep feeding just as much of the fresh solids as possible.

At the Rahway plant we try to maintain a pH between 7.1 and 7.2. It has been noticed time and time again that, during conditions of over-loading, the pH will drop very slowly to about 7.0, and then will decrease within the course of 2 or 3 days to 5.3 where it seems to become stabilized. If a little lime is added when the pH is dropping between 7.1 and 7.0, the solution can be buffered and the pH held in that range. If, however, the pH gets below 7.0, tons and tons of lime are needed to bring it back up to where it should be.

Perhaps there is a different type of water in New Jersey; but, from experience, we have been able to continue sustained loadings of about 20 per cent more with lime than without lime. For the past three years, our solids loading has been about 5½ lb. of solids per cubic foot per month. With that, we have destroyed 50 per cent of the volatile material in the primary tank, and an additional 10 per cent in the secondary.

It has been our experience that without lime our capacity is decreased about 20 per cent. It seems to be cheaper to add a little lime (in our case about 15 per cent of lime on the dry basis of solids in the tank) than to provide the necessary additional capacity.

*K. E. Foote, Superintendent of Disposal Plants, New Haven, Conn.:* When the New Haven digesters were put in operation, the first one was fairly dormant for several months. The supernatant was foul, and the pH was around 5. No lime was added. As a result of experiments with a small digester in the laboratory, lime was added to the second digester when it was started. That digester produced gas in about 28 days, whereas the first tank had run several months. There were even articles in the newspapers about not being able to get the gas production going at the sewage plant.

The digesters were designed on the basis of 1 cu. ft. per capita, with a population of 87,000; the population now is estimated at 110,000, and probably digestion capacity is about 0.6 cu. ft., or at most 0.75 cu. ft., per capita.

The addition of lime seems to increase the capacity of the digesters. We can put a little more fresh material into the tanks than we would be able to without lime. My advice, therefore, is to use lime if it helps in any particular case; if not, leave it alone.

*W. Rudolfs, Chairman, Dept. of Sanitation, N. J. Agricultural Experiment Station, Rutgers University:* It is worthwhile noting that the opinions expressed here seem to show a division between the Eastern United States and the Middle West. The water in the East is soft; that in the Middle West is hard. That probably accounts for the differences in the theories.

## FROM ACTIVATED SLUDGE TO ACTIVATED SUDS AT BATAVIA, ILLINOIS

As if normal problems of industrial waste interference with the activated sludge process were not enough to plague Frank W. Olson, superintendent of sewage treatment at Batavia, Ill., in August, 1949, the aerators at the larger of the two Batavia plants began a violent frothing that has continued unabated throughout ensuing months. The sudsy supercharge, besides being bulky, sticky, smelly, and generally physically bothersome in the

plant itself, has resulted in deterioration of both the plant effluent and the settling qualities of the aeration liquid.

## Plant Description

The main plant at Batavia employs mechanical aeration for activated sludge treatment handling combined sewer flow from an estimated (1945) population of 4,200. The design flow of 0.6 m.g.d. was based on 6,000 population. Main units of the plant include manually cleaned bar racks, grit chambers, primary settling tanks, mechanical aerators, secondary settling tanks, postchlorination contact tank, and open sludge drying beds. Mechanical removal of solids is provided only in the secondary settling tanks. The gas produced by separate sludge digestion is used in heating the digester and the plant buildings.

Since the plant was placed in operation in 1936 some trouble has been experienced periodically with industrial waste flows to the plant. However, informal surveys for industrial wastes were inconclusive, although a survey of the treatment plant by State Health Department personnel showed the plant itself to be adequate.

## Local Industries

The major sources of industrial wastes tributary to the plant seem to be a milk processing plant and two steel products plants. Some time ago the dairy introduced vacuum processing equipment. Detergents used in equipment cleanup are believed to contribute to the problem. Moreover, both steel plants use a type of "degreaser"; one for removing oil and grease before painting and baking, the other for cleaning after case-hardening machine parts.

## New Problems

In August, 1949, violent frothing of the aerators (see Figures 1 and 2) indicated a new source of trouble. At first it was thought to be a temporary condition, but the activity has increased with the passage of time.

The color of the raw sewage is mostly dirty gray, with occasional flows of pure white liquid. For about 15 min. during the latter part of each week a light greenish-yellow color appears. The pH normally is about 7.8, although on rare occasions it is higher or lower; the B.O.D. ranges from 250 to more than 400 p.p.m.

There is reason to believe that the worst periods of frothing should occur on Monday afternoons or Tuesdays, after the washday activities on Monday mornings. However, such is not the case; Thursdays through Sundays seem to be the banner days for "forever blowing bubbles." Colder temperatures seem to have no effect on reducing the amount of froth produced, as the largest "head" (6 ft. above the aerator walkways) occurred when the liquid temperature was 50° F.

The frothy mass has a foul odor strongly suggestive of sour milk or an unclean cow barn. Its general appearance is that of king-size soap suds. It will break down under hosing and most of it can be forced back into the aerators; but it will re-form almost immediately. Wherever the froth touches tank walls and similar surfaces it smears them with fat and grease. Where it has overflowed there is left a fatty, sticky substance that chokes the grass. When dried, a process that takes considerable time, it can be raked up as large, hard flakes. If the sun hits the grease-smeared tank walls, scraping is required to remove the "fried" residue, as hosing is ineffective.

In the influent channel to the clarifier there has been noticed a white, thin blanket of granular material floating behind the black formation that forms. The latter is as tough as leather when skimmed from the channel. A few days after a heavy dose of industrial waste is received, the clarifier efflu-

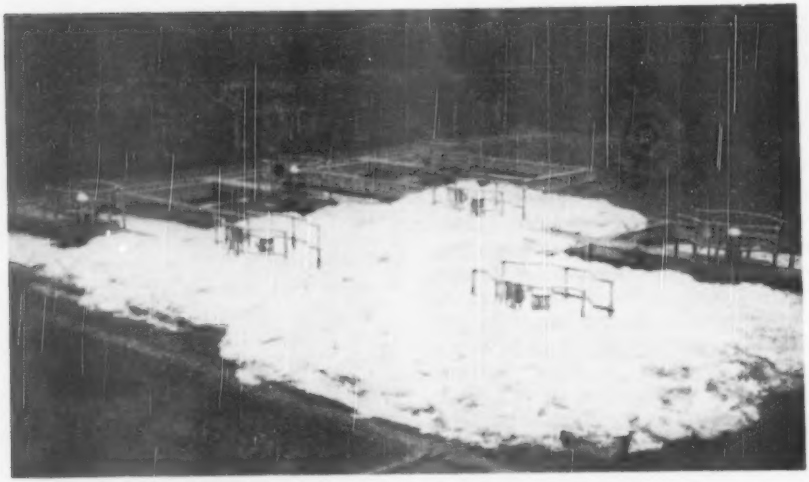

FIGURE 1.—Aerators at Batavia, Ill., buried in suds.

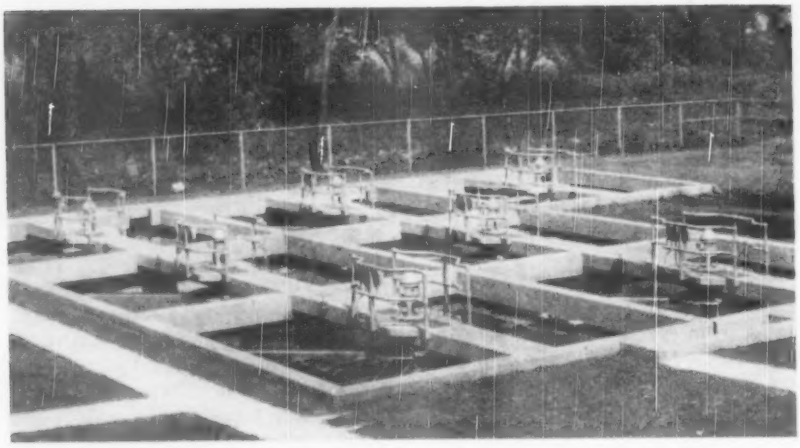

FIGURE 2.—What's under the froth.

ent channels will be coated with a ⅛-in. thick residue of a sticky light-brown substance that is believed to be the settling from raw milk.

Settling qualities of the aeration liquid have become very poor. The really heavy suspended solids will settle out in a solid mass, the remainder being light brown in color and sometimes taking days to settle.

### Effluent Deterioration

On days when noticeable waste discharges are received at the plant, the effluent shows the effects in striking manner. Rather than its usual clarity, it then exhibits considerable turbidity and, at times, some color. The dissolved oxygen content is about 3 p.p.m.; the stability, from 1 to 2 days. However, the B.O.D. and suspended

solids, instead of ranging between 6 and 10 p.p.m. as normally, increase to between 16 and more than 30 p.p.m.

The same conditions exist in the digester. The supernatant is very heavy, and of the same color as the liquor. Sludge drawn to the drying beds is black, sluggish, and sticky. After standing for 24 hr., the same light-brown fluid as previously noted floats on top, and a very foul odor is given off. The odor persists for weeks, as the sludge takes a long time to dry. When dry, it is as hard as rock.

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# STARTING THE OPERATION OF THE ABINGTON TOWNSHIP SEWAGE TREATMENT PLANT *

By R. M. Bolenius

*Chemist, Abington Township Sewage Treatment Plant, Abington, Pa.*

Abington Township, which is primarily a residential district located just north of Philadelphia, Pa., has an area of 14.88 sq. mi. Prior to 1947, only a very small area of the Township was served by sanitary sewers, which discharged into the Philadelphia sewerage system. Sewage from the majority of the homes was treated on the immediate premises in septic tanks and cesspools. From 1920 to 1940 the problem of sewage treatment became more and more troublesome because of the extremely rapid growth in population.

In 1941, therefore, a consulting engineer was engaged to design and supervise the construction of an extensive system of sanitary sewers and a sewage treatment plant. Construction of the project was started on March 1, 1947.

The resulting sewerage system consists of sanitary sewers designed to serve Abington Township and small portions of adjoining Cheltenham, Springfield, and Upper Dublin Townships. The sewage treatment plant is designed to employ activated sludge treatment of the diffused air type with heated separate sludge digestion and covered sludge drying beds.

* Presented at 21st Annual Conference, Pennsylvania Sewage and Industrial Wastes Association; State College, Pa.; Aug. 24–26, 1949.

## Treatment Plant Description

The sewage treatment plant (Figure 1), located in Upper Dublin Township, is designed on a basis of 75 g.c.d., with infiltration in the sanitary sewer system estimated at 500 g.p.d. per inch diameter per mile of sewer. The design population, projected to 1966, is 20,100; design flows are as follows:

| | |
|---|---|
| Total daily flow ..... | 1.919 m.g.d. |
| Average hourly flow ..... | 2.420 m.g.d. |
| Maximum hourly flow .... | 3.425 m.g.d. |

A comminutor is provided for shredding large solids. A pumping station employing two pumps, either of which will accommodate the present estimated flows, is incorporated into the plant to lift the sewage to the flow level. Each of the pumps is driven by a wound-rotor motor having four steps of operation. Float switch controls provide automatic pumping rates ranging from 750 to 4,000 g.p.m. in six successive steps. When flows increase to a point where it becomes necessary to use the second pump extensively, a third pump is to be installed to provide a spare for emergency use.

### *Main Units*

The plant is designed to provide ultimately the following plant units (Figure 2), the specified detention periods being based on the design average hourly flow:

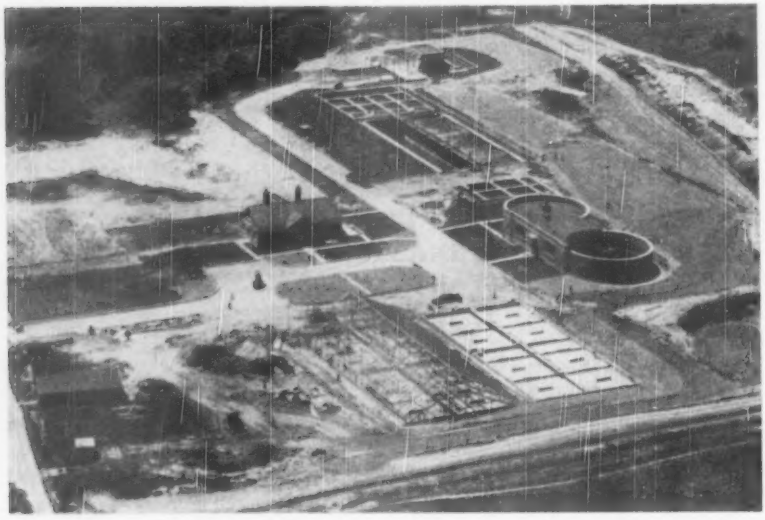

FIGURE 1.—Aerial view showing partial operation of Abington Township (Pa.) activated sludge plant during construction.

2 primary settling tanks (1.04 hr.)
2 aeration tanks, with swing diffusers (6 hr., including provision for 25 per cent return sludge)
2 air blowers (0.971 cu. ft. of air per gal.)
4 secondary settling tanks (2.5 hr.)
2 chlorine contact tanks (22.5 min.)
2 sludge digestion tanks with floating covers (4.53 cu. ft. per capita)
2 covered sludge drying beds (0.74 sq. ft. per capita).

All of the structures as described have been constructed. However, only one of the primary settling tanks and two of the secondary settling tanks are presently provided with sludge collector mechanisms; only one of the sludge digestion tanks is equipped with the floating cover; and only one of the drying beds is covered. The equipment necessary to complete these units is to be provided and installed under future contract at such time as the plant loading becomes sufficient to warrant the necessary expenditures.

For sludge handling, two 200-g.p.m. raw sludge pumps are provided. Two activated sludge recirculating pumps provide a possible return of 30 per cent with one pump in operation and 60 per cent of the design daily flow with both pumps in operation. Each of these return sludge pumps is driven by a motor with eleven variations in speed and will deliver quantities ranging from 100 to 500 g.p.m. A centrifugal sludge recirculating pump and a plunger-type sludge transfer pump provide the facilities for handling digested sludge.

The sludge digestion tanks have provisions for sludge pre-heating and the digester piping is arranged to allow the tanks to be operated as stage digesters.

*Auxiliary Systems*

In addition to the main plant units as described, the following equipment and systems are also provided:

1. A gas collecting and burning system utilizing the gas as fuel for heating the digester contents, for building heat, and to provide hot water for plant consumption.

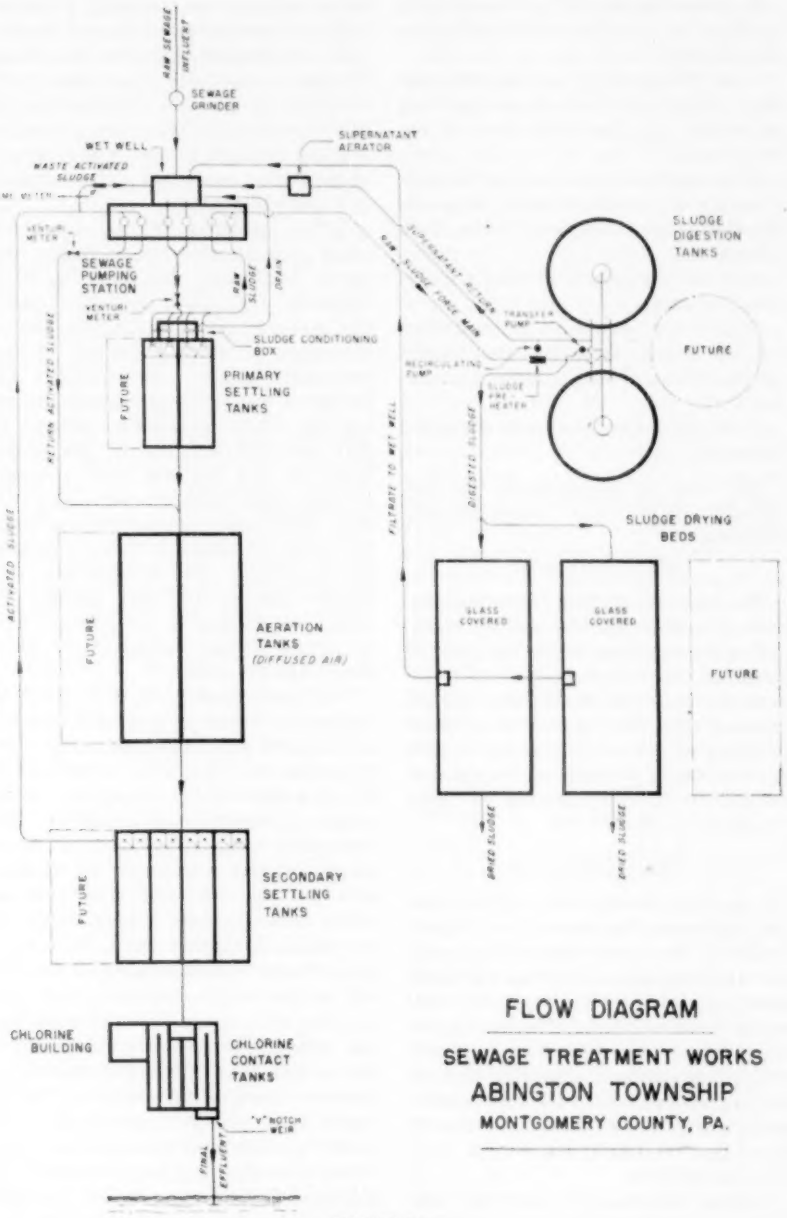
RAW SEWAGE INFLUENT
SEWAGE GRINDER
WET WELL
SUPERNATANT AERATOR
WASTE ACTIVATED SLUDGE
VENTURI METER
SEWAGE PUMPING STATION
RAW SLUDGE
DRAIN
SLUDGE CONDITIONING BOX
PRIMARY SETTLING TANKS
FUTURE
SLUDGE DIGESTION TANKS
FUTURE
TRANSFER PUMP
RECIRCULATING PUMP
SLUDGE FIRE HEATER
SUPERNATANT RETURN
RAW SLUDGE FORCE MAIN
RETURN ACTIVATED SLUDGE
ACTIVATED SLUDGE
FILTRATE TO WET WELL
DIGESTED SLUDGE
SLUDGE DRYING BEDS
GLASS COVERED
GLASS COVERED
FUTURE
DRIED SLUDGE
DRIED SLUDGE
AERATION TANKS (DIFFUSED AIR)
FUTURE
SECONDARY SETTLING TANKS
FUTURE
CHLORINE BUILDING
CHLORINE CONTACT TANKS
"V" NOTCH WEIR
FINAL EFFLUENT
FLOW DIAGRAM
SEWAGE TREATMENT WORKS
ABINGTON TOWNSHIP
MONTGOMERY COUNTY, PA.

FIGURE 2.

2. A chlorine application system with facilities for pre-chlorination, and post-chlorination.

3. A utility water system utilizing plant effluent for flushing connections on meters and for wash-down of various tanks.

4. A selector and an aerator for conditioning supernatant liquor from the digesters prior to discharge to the plant influent.

5. A raw sludge conditioning and dewatering tank.

6. Metering equipment for recording influent sewage flow, activated sludge return, activated sludge waste, and diffused air.

7. A compact but very well equipped laboratory.

The cost of constructing the described plant was approximately $700,000.

## Plant Personnel

The plant operating personnel consists of a chief operator and an assistant operator, employed on the basis of previous experience in sewage treatment plant operation and supervision, together with four attendants without previous experience or training in sewage treatment, but selected locally and trained to the performance of their duties on the job.

## Plant Operation

Construction of the sewer system and the treatment plant was started March 1, 1947. The sewer construction project was programmed so that the areas most urgently needing such facilities would be served first. The urgency of the situation was such that in April, 1948, it was deemed advisable to start making connections to the incompleted system, despite the fact that some of the major treatment plant units were still incomplete.

Critical shortage of materials was primarily responsible for the condition. Motors and pumps, on order for more than a year, were still not available. As a result, it was necessary to install sufficient temporary equipment to provide a reasonable degree of treatment. Treatment facilities were thus made available to provide comminution of solids, primary sedimentation, aeration without facilities for the return of activated sludge, secondary sedimentation, and post-chlorination.

Thus, operation of the treatment plant was started under rather unusual conditions. By May 12, 1948, sufficient connections had been made to the sewer system that it was deemed necessary to start operation of the treatment plant. Accordingly, the bulkhead was removed from the intercepting sewer, permitting sewage to flow into the wet well of the plant. Prior to this the wet well, primary settling tanks, aerators, secondary settling tanks, and chlorine contact tanks had been checked for water tightness and approved. The comminutor, two sewage pumps, and the sludge collector mechanisms in the primary and secondary settling tanks had also been tested and approved.

For approximately the first month of operation, treatment consisted of comminution of gross solids, primary sedimentation, aeration without the return of activated sludge, secondary sedimentation, and post-chlorination. All the sludge removed by secondary sedimentation was withdrawn by gravity into the wet well and permitted to settle with the raw sludge solids in the primary settling tank. The mixture of raw settled solids and secondary sludge was withdrawn from the primary tank by gravity and stored in the primary tank not equipped with sludge collectors. This procedure was necessary because the sludge digestion tanks were not yet completed. In order to prevent odor nuisance and retard putrefaction, frequent doses of chlorinated lime were added to this tank. This treatment proved to be quite effective and completely eliminated the odor problem.

During this period, the treatment units and installed mechanical equipment operated satisfactorily. The flow meters were not yet installed so that no record of the volume of sewage treated is available. Laboratory facilities were also extremely limited during this early period. However, methylene blue tests indicated that the secondary effluent before chlorination had a relative stability of 99 per cent. Residual chlorine tests were made on samples of plant effluent every 2 hr., with an average of 0.3 p.p.m. being maintained.

*Progressive Changes*

On June 7, one raw sludge pump and the uncovered digestion tank were ready for use. Immediately, all the sludge previously stored in the primary settling tank was pumped into this digestion tank. Continuation of the practice of dosing with chlorinated lime successfully prevented odor nuisance.

Progressive changes in operating procedures were made as the various treatment units and mechanical equipment were completed and made available for use. The various metering devices were placed in operation on June 29. Most of the laboratory equipment was received in July. The covered sludge digestion tank and sludge heater were placed in operation in September, and on November 4 the plant finally went into full operation with installation of the permanent motors on the blowers and return sludge pumping facilities.

In placing the covered sludge digestion tank in service, the tank was first filled with raw sewage pumped from the primary settling tank hoppers. The preheater was then placed in service on manual operation until the tank contents reached 90° F., using manufactured gas as fuel. This temperature was then maintained by switching the preheater to automatic operation with the sludge thermostat set at 90° F.

The raw sludge removed in treatment at this time averaged 600 cu. ft. per week and was pumped into the covered and heated digestion tank twice weekly. Small increments of sludge were transferred daily from the uncovered digestion tank to the covered and heated tank, until all the stored sludge had been transferred. Small quantities of lime were added to the fresh raw sludge solids, as required, to prevent excessive acidity. By following this procedure, no unusual difficulties were encountered in starting digester operation. The gas produced in the digester was wasted for two weeks. At the end of this time a burnable gas was being produced and the pressure regulator was adjusted to employ a mixture of sewage gas and sufficient manufactured gas to satisfy the fuel requirements in all heating units. Average gas production for the first month of digester operation was 0.83 cu. ft. per capita per day. With the development of a balanced digester, gas production has increased steadily until at present the average production is 1.07 cu. ft. per capita per day.

*Activated Sludge Return*

With the initiation of full operation on November 4, return of secondary settling tank sludge to the head of the aerator became normal operating procedure. The production of activated sludge floc proceeded slowly, as a very weak sewage was being treated. After a month of such operation, the concentration of suspended solids in the aerator was 800 p.p.m. During this development period, the clarification accomplished improved consistently, as was expected. Oxidation was being accomplished, as evidenced by the production of 10 p.p.m. of nitrate nitrogen in the secondary effluent. As the activated sludge floc continued to develop, optimum results were found to

be attained with a suspended solids concentration of 1,500 to 1,800 p.p.m. in the aerator. This concentration has been maintained by wasting the excess activated sludge solids to the primary settling tank. The resultant activated sludge settles very well and has an average sludge volume index of 75.

From previous operating experience and by careful study of equipment manufacturer's instruction bulletins, complete maintenance and lubrication schedules were drawn up and made a part of plant operating procedure as rapidly as they could be processed. A complete record system of inspection, lubrication, and maintenance has been established and printed plant operation and performance record forms provide permanent record of plant accomplishment.

## Difficulties Encountered

In spite of inspection, unusual happenings and mechanical difficulties occurred, as could be expected with any such complex, highly mechanized system. Some of these mishaps were directly attributable to the fact that plant operation was started while a sizeable section of the plant was still under construction, others were due to faulty workmanship, and still others were those normally anticipated in starting new equipment. Examples of these difficulties included:

1. A bulldozer pulled up and severed an electrical conduit. Fortunately, this was on a lighting circuit and so did not interrupt plant operation.

2. In placing the metering devices in operation, check valves on the flushing water lines were found to be installed operating in the wrong direction.

3. Periodic blower shut-downs were traced to a lose set of V-belts that had not been adequately adjusted.

4. A flame trap was discovered installed in reverse position.

5. On emptying the primary and secondary settling tanks for routine cleaning and inspection, a number of flights were found to be attached to the collector chains with the nuts only finger tight on the bolts. Needless to say, all were immediately checked and tightened.

6. Stray pieces of lumber, bolts, iron, and concrete worked their way into, and were found in, the most unusual and troublesome locations.

7. Hardened concrete and paint proved troublesome and annoying on the surface of diffuser tubes.

8. In spite of warnings to the contrary, cesspool cleanings were dumped into out-of-the-way manholes by so-called sanitary excavators.

9. Pocketing of sludge in the corners of the sludge hoppers in the primary and secondary settling tanks proved troublesome. The installation of movable water jets in these hoppers proved very effective in solving this problem.

In addition, a wide variety of minor adjustments and replacements on mechanical equipment made life interesting.

## Plant Performance

Plant operating efficiency on the whole has been very good. Since November, 1948, when laboratory facilities became fully available, the secondary effluent before chlorination has averaged 11 p.p.m. suspended solids, 8 p.p.m. 5-day B.O.D., 7.1 p.p.m. dissolved oxygen, 12 p.p.m. nitrate nitrogen, and 99 per cent relative stability. An average of 0.3 p.p.m. of residual chlorine has been maintained in the plant effluent. During this period, the average sewage flow increased from a monthly average of 0.537 m.g.d. to 0.657 m.g.d.

## Comments

The first year of operation of the Abington Township sewage treatment plant, although having some unusual circumstances, was, by and large, typical of starting an activated sludge plant. A considerable amount of time

was spent in preparing adequate operating, maintenance, and performance report forms; arranging for the purchase of necessary tools, supplies, and safety equipment; and making the adjustments and repairs always necessary with new equipment. Many experiences have not been mentioned. In general, however, all were educational and informative and have materially increased the knowledge of plant personnel on the subject of the function and maintenance of the equipment and treatment units.

## HEAVY-DUTY RAKE FOR DRY SAND FILTERS

By N. C. Avery

*Supervisor of Plant and Maintenance, The Southbury Training School, Southbury, Conn.*

One of the handiest gadgets devised by W. Smith, operator of the Southbury Training School sewage treatment plant, is a special heavy-duty rake for keeping the surface of the sand filters well broken up.

The plant serving the institution, which is a state school for handicapped children, treats the sewage and institutional wastes from a population of 1,600. All work at the plant is done by one employee with 6 "middle mentality" boy inmates of the school as helpers.

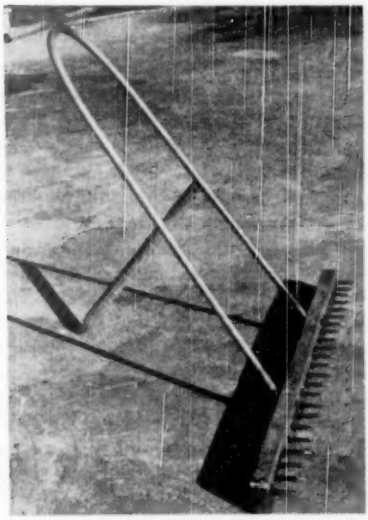

FIGURE 1.

Settled sewage is spread on 12 sand filter beds comprising 3 acres in all. Considerable trouble had been experienced in keeping the surface of the filters from becoming hard and impervious. Raking with an ordinary garden rake was laborious, and the boys did not get the job done well enough to get good results.

The special rake (Figure 1) consists of a piece of hard 2 in. by 4 in. native oak, about 4 ft. long, through which are inserted 24 lag screws 4½ in. long and sharpened on the end by a local blacksmith. The sharpening also served to harden the points. Oak was chosen for the crosspiece because of its toughness and its weight.

To the oaken crosspiece is attached a handle made of bent ordinary pipe, with a crossbar welded at the loop. The handle is angled up from the oaken crosspiece at a convenient angle and length for dragging.

To use the rake, the boys get inside the handle and drag it, "playing horse" and having fun, as well as doing a good job of softening the sand surface. With the rake, a boy can cover one bed (¼ acre) one way in about 6 min. Generally, raking in one direction suffices, but the first time it is done it may be well to rake first lengthwise, then crosswise.

# SOLVING A DIGESTER SCUM PROBLEM *

By Leonard Hillis

*Superintendent, Sewage Treatment Plant, Caro State Hospital, Caro, Mich.*

Although many of the troubles experienced with the sludge digestion tank at the Caro State Hospital sewage treatment plant may not be unique, the solution of the problem may provide ideas and incentive to others faced with similar difficulties.

The 90,000-gal. digester was put in operation in 1940. Since that time a considerable quantity of floating materials, including seeds, matches, hair, rubber articles, gauze, and other fabric materials shredded by the comminutor, had accumulated in it, together with kitchen fats and other greases that are very difficult to digest. Most of this accumulation naturally rose to the top, carrying with it sludge particles that would have settled had they not been held there by the light material.

## No Stirring Provided

If there had been provisions for stirring this scum, or recirculating supernatant liquor to the top and center of the digester, it is quite likely that a large part of the scum would have been digested and made to settle out. Under the existing conditions, however, it kept collecting during 9 years of operation, until so much space was occupied by it—space needed for active digestion—that it became necessary to do something about the situation. Therefore, in 1948 some serious thinking was done regarding the matter. After correspondence with the cover manufacturer, a plunger pump was purchased and installed on the floating cover for the purpose of recirculating supernatant liquor to the top and center of the scum layer.

This proved successful to the point that it started breaking of the scum, but as chunks broke off at the center some of them would be picked up by the pump suction. The result—a plugged pump. A screen could not be used on the lower end of the suction pipe because it also would become clogged and would present difficulty in removing for cleaning. After several trials with the same results, this method of disposing of the scum was given up as unsuccessful. It was decided at that time that the digester would have to be emptied to solve the problem.

On May 2, 1949, men from the institution's maintenance crew made temporary connections and laid pipe to the natural lagoon, into which the digester contents, along with the water that would be necessary to break up the scum, were to be put. One man from the maintenance crew helped the operator during the entire process.

## Final Tank Made a Digester

The drying bed was filled to capacity. A final tank that was not in operation at the time was filled about two-thirds (13,000 gal.) with digested sludge for seed, the remaining space to be used for raw sludge, thus making a digester out of the final tank until all could be pumped to the digester. The secondary treatment of the primary effluent went on as usual, but the operator had no time for laboratory tests.

Breaking of the scum layer by using the fire hose was begun Monday about 2 P.M. Working only the regular 8-hr. day (both operator and helper being tired enough to quit at that time), the job was completed Saturday noon, May 7.

No serious difficulties were encoun-

* Reprinted from the June, 1949, number of *Michigan Sewage Works Bulletin*, issued by the Bureau of Engineering, Michigan Department of Health.

tered. The pump (raw sludge pump) failed a number of times when too large a slug would get into the line or something would get stuck under one of the balls. At times, when the mixture being pumped was thin enough, the return sludge pump was cut out of its regular duty for short periods and kicked in to aid the emptying procedure.

Breaking up of the scum was a slow process. Possibly 500,000 gal. of water were used. Having a natural lagoon to accommodate all this water, along with the remaining digester content, was fortunate. It was necessary to man the fire hose through the cover manhole until it was absolutely safe to go below the cover. On the bottom and covering the heating coil next to the sludge inlet was a large deposit of sand. This sand was difficult to remove through the pipes to the lagoon, so after all other materials had been flushed out to the lagoon and only the sandy deposit remained, it was quite easily flushed and pumped to the river because of the low head at which it had to be pumped. Pollution of the receiving water from this sand mixture was negligible and presented no problem at the river outfall. Only the sand in the very bottom (the sump) had to be removed by rope and pail.

### No Digester Damage

On inspecting the interior of the digester, the heating coil was found to be covered with scale that ranged from 1/16 to 3/16 in. thick on the top and bottom, to paper thin in some places on the sides. When this scale was removed, the coil appeared to be in excellent condition. The under side of the cover showed little signs of deterioration.

By Saturday evening the stored digested and raw sludge and enough sewage were pumped into the digester to cover the heating coil. The temperature of this mixture was about 65° F. Only raw sludge, but all of it, was added thereafter. By May 12, the temperature was up to 88° F. and the pH was 7.0. On the 16th a temperature of 91° was reached; it has not fallen below 90° since. The pH remained at 7.0 until June 6, when the test showed 7.1.

The cover was not floated and the gas seals closed until May 20. Within a short time, the gas pressure reached 6 in. of water. It has remained at that point, and the waste gas burner has been in operation constantly since that time. Hot water for general use is being heated by the gas and there would be plenty for the gas boiler (used for heating the digester) if it were in commission. On June 7 the digester was nearly filled to the automatic supernatant drawoff, which should operate successfully as there is no thick scum to interfere.

### Circulation Now Provided

The pump mentioned earlier, that was installed in 1948 to recirculate supernatant liquor to the top and center of the cover, is now in operation about 2 hr. of each day that the operator is on duty. The suspended solids content of the recirculating liquor has ranged from 197 to 434 p.p.m.

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## TIPS AND QUIPS

### Choked Filters

An excellent example of the need for efficient ventilation of trickling filters is contained in a paper by A. J. Booth on "Design and Operation of Sewage Works in the Guildford Rural District."* Mr Booth, manager of the

* Presented at a meeting of the Metropolitan and Southern Branch, Institute of Sewage Purification; London, Eng.; Nov. 26, 1949.

District works, explained the difficulties and their solution as follows:

"At the Wood Street works the filter wall was built of concrete block laid directly on the floor of the filter. The remainder of the floor was covered with patent drainage tiles; the medium was of clinker, 6 ft. in depth.

"Ventilation pipes were placed at intervals of 8 ft. around the circumference of the bed. Effluent drained to a well at the center of the filter, the bottom three courses of the well wall being of honeycomb brickwork. The filter was put in operation during the autumn of 1947. It matured well and was soon producing a satisfactory effluent. During the summer of 1948 it was producing quite a good effluent, but I was not entirely satisfied and I had the ventilation pipes flushed out. During the late autumn of 1948 the filter surface became covered with a gray growth, so I had a small portion of the 3-in. concrete fillet around the base of the filter wall removed and a number of vents made so that air could penetrate through the base of the wall to the underside of the drainage tiles. The result was astounding. Within 7 days a portion of the filter surface, about 2 ft. square, had completely cleared and within 3 weeks the whole of the surface had cleared. Huge quantities of humus came away with the effluent. Since then no further trouble has been experienced."

This striking demonstration of the need for oxygen in aerobic treatment processes may suggest similar treatment for ponding filters elsewhere. A note of caution is in order, however, as the more rapid circulation of air through the filter medium is likely to defeat its primary purpose by freezing up the whole mass during below-freezing weather.

## Mail Order Chemistry?

A correspondence course in Sewage Chemistry is tentatively being planned for Florida operators by the General Extension Division of the University of Florida. The course, to be offered without academic university credit, normally would cost the individual only about $10. It is planned to have the courses well prepared by men familiar with the everyday needs of sewage works men.

Here's a new adaptation of the correspondence school idea. Perhaps, if enough interest were evidenced in other localities and in other phases of sewage treatment operation and control, other university extension divisions could be interested in such specialized courses. It might even be that suitable recognition, in the form of certificates of completion, could be awarded at the annual Short Course and School to those who passed the course.

Sharpen those pencils—here comes the mailman!

## How It's Done in South Africa

One picture being worth 10,000 words, we present Figure 1 to show how one plant maintenance and beautification program has been designed to take advantage of local materials to reduce grounds maintenance costs. The plant, located at Potchefstroom Municipality (approximately 100 mi. southwest of Johannesburg in the Transvaal of South Africa), provides intermediate biological treatment for a population of nearly 10,000. The flowsheet calls for screening, primary settling, high-rate filtration, secondary settling, and two-stage sludge digestion.

Among the unusual features to be found at this plant is the use of river-washed gravel of 1-in. to 1½-in. size as a landscaping item in the yard areas. As shown, grassed areas are sharply reduced and "formal" in appearance, all edges and working areas around the plant units being gravel treated. The time saved in grass cutting more than compensates for any cost necessitated by weed control in the graveled areas, which also precludes any "mangy" appearing lawns caused by excess foot traffic.

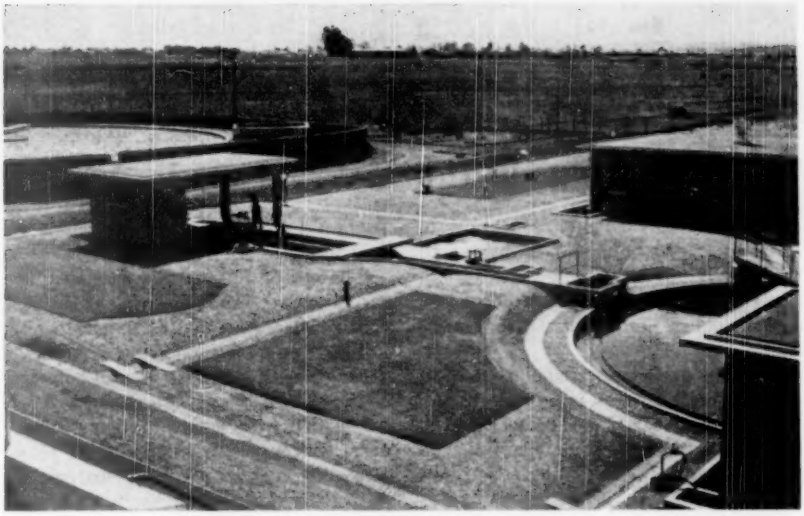

FIGURE 1.—These striking grounds of a South African treatment plant result from large-scale use of gravel in yard areas.

Also noteworthy are what appear in the foreground to be walks, but which are actually brick-lined drain ditches to carry off surface water in the flat plant area; the pole-mounted floodlights strategically placed for illuminating night operations; and the screening hedge around the dosing tank and filter.

Does the layout suggest any ideas on how to dress up your own plant without increasing the housekeeping chores unduly?

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### The Sewage Plant Operator Has a Headache

A sudden storm, and comes the filthy flood
With floating trash and murky sticky mud;
Or smelly slimy sludge and oily sheen,
And grit and grease; in color gray or green,
Or brown, or black, or even blended blue,
Mayhap with rusty reddish hostile hue;
In soapy silence stained with scarlet sin,
A fearful fretful treatment to begin,
It slithers through the helpless gaping gates,
Then coils and curls and churns on choking grates.
The all-shift shepherd stares in stunned alarm.
How save his charge and B.O.D. from harm?

For Member Association Meetings
see page 460

# Editorial

## A FEDERATION FACT OF LIFE

The ambitious move to monthly publication of this Journal is now well underway. With a single exception, the expanded operation has been accomplished in highly satisfactory fashion.

The disappointing element—that of advertising support—is extremely important, however, for it is the advertising revenue that determines the amount of technical material that can be published. A net advertising income of $40,000 was anticipated in the 1950 Federation budget, and exactly the same amount was appropriated to cover the Journal printing and mailing bill for the year. Advertising space contracted to date is far from sufficient to yield the amount of revenue that is budgeted and needed.

Advertising space in the Journal is sold strictly on its merits, for it is indeed an effective medium. Surveys conducted by advertisers time and again have demonstrated a readership strength that is enviable in the sanitary engineering field. Circulation coverage among consulting engineers specializing in waste disposal problems, and among supervisory sewage works operation personnel is unexcelled. Present growth is mainly among technical personnel of large industries, which represent a virile market for equipment.

But there is an additional reason why manufacturers should advertise in the Journal. Where would the science of sewage and industrial waste treatment be today without the Federation and its publications? Where would the professional art of sewage works operation be—and the present market? It should not be necessary to point out that an obligation exists.

The sale of Journal advertising space is one of the responsibilities of the Executive Secretary-Editor. Until now it has been possible to meet the need through mail promotion and personal contact, and these efforts have been intensified with determination to overcome the present emergency. However, our readers can help materially, and their aid is solicited. Here is how the loyal reader can help:

1. Read the advertising. It is a splendid source of information on up-to-date developments and trends.

2. Notice who is—and who is not—supporting the Federation and *your* Journal by way of advertising participation.

3. Whenever you can do so, give Journal advertisers the preference of your patronage.

4. As you make inquiries or write for bulletins or catalogues that are mentioned in advertisements, be sure to state that you read about it in SEWAGE AND INDUSTRIAL WASTES!

Our faithful advertisers have asked no special favors and have received none. Several of them have used space in every single issue, and are well satisfied with the results. They expect no thanks, but they deserve the gratitude of every reader and user of the Journal. They identify themselves as a highly important element in the structure of the Federation, for without advertisers there would be no Journal at all.

W. H. W.

Federation of Sewage Works Associations

# Annual Year Book and Directory

## 1950

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OFFICERS

PAST PRESIDENTS

HONORS AND AWARDS

ANNUAL MEETINGS AND CONVENTIONS

DIRECTORY OF COMMITTEES

MEMBERSHIP SUMMARY

DIRECTORY OF MEMBERS

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FEDERATION OF SEWAGE WORKS ASSOCIATIONS, INC.

325 Illinois Building, Champaign, Ill.

## 1949–50 OFFICERS

*President:* A. H. Niles

*Vice-President:* R. E. Fuhrman

*Treasurer:* W. W. DeBerard

*Executive Secretary-Editor:* W. H. Wisely

*Advisory Editor:* F. W. Mohlman

## PAST PRESIDENTS

| *Name* | *Period Served* |
|---|---|
| Charles A. Emerson | 1928–41 |
| *Arthur S. Bedell | 1941–42 |
| George J. Schroepfer | 1942–43 |
| A. M. Rawn | 1943–44 |
| Albert E. Berry | 1944–45 |
| John K. Hoskins | 1945–46 |
| Francis S. Friel | 1946–47 |
| George S. Russell | 1947–48 |
| V. M. Ehlers | 1948–49 |

## HONORS AND AWARDS

### Honorary Members

The qualifications for Honorary membership in the Federation are set forth in Article II, Section 4 of the By-laws. Honorary Members are elected upon recommendation by a committee comprising the President and four latest Past Presidents, the senior Past President as chairman, in accordance with a policy adopted by the Board of Control on October 23, 1943. Honorary Members elected to date are as follows:

| | |
|---|---|
| Charles Alvin Emerson | 1941 |
| *Arthur S. Bedell | 1942 |
| Julius W. Bugbee | 1942 |
| Langdon Pearse | 1942 |
| Charles Gilman Hyde | 1943 |
| Howard Eugene Moses | 1943 |
| Floyd William Mohlman | 1944 |
| Willem Rudolfs | 1945 |
| William John Orchard | 1946 |
| F. Wellington Gilcreas | 1948 |

### The Harrison Prescott Eddy Medal

The Harrison Prescott Eddy Medal is awarded annually to a member of any Member Association of the Federation for outstanding research contributing in important degree to the existing knowledge of the fundamental principles or processes of sewage treatment, as comprehensively described and published during any stated year in SEWAGE AND INDUSTRIAL WASTES. The award commemorates Harrison Prescott Eddy, a famous engineer and a pioneer in the art of sewage treatment.

* Deceased.

Past recipients of the award are:

Harry Willard Gehm....1943
John Raymond Snell....1944
Lloyd R. Setter....1945
H. Heukelekian....1946
Richard Pomeroy and Fred D. Bowlus....1947
F. W. Kittrell and O. W. Kochtitzky, Jr. ....1948
John W. Hood....1949

### The George Bradley Gascoigne Medal

The George Bradley Gascoigne Medal is awarded annually to a member of any Member Association of the Federation for outstanding contribution to the art of sewage treatment works operation through the successful solution of important and complicated operational problems, as comprehensively described and published during any stated year in SEWAGE AND INDUSTRIAL WASTES. This award is in memory of George Bradley Gascoigne, a prominent consultant from 1922 to 1940, who demonstrated an unusual interest in matters of sewage works operation.

Past recipients of this award are:

Kerwin L. Mick....1943
James T. Lynch and Uhl T. Mann....1944
John D. McDonald....1945
LeRoy Winfield Van Kleeck....1946
Leon S. Kraus....1947
David P. Backmeyer....1948
Wilbur N. Torpey....1949

### The Charles Alvin Emerson Medal

The Charles Alvin Emerson Medal is awarded annually to a member of any Member Association of the Federation "for outstanding service in the sewerage and sewage treatment works field, as related particularly to the problems and activities of the Federation of Sewage Works Associations in such terms as the stimulation of membership, improving standards of operational accomplishments, fostering fundamental research, etc." This award honors Charles Alvin Emerson, who served as President of the Federation from 1928 to 1941 and holds the distinction of being its first Honorary Member.

Past recipients are:

Floyd William Mohlman....1943
Willem Rudolfs....1944
Harold Warner Streeter....1945
F. Wellington Gilcreas....1946
Langdon Pearse....1947
LeRoy Winfield Van Kleeck....1948
William J. Orchard....1949

### The Kenneth Allen Award

From 1943 through 1948, meritorious personal service to the Member Associations of the Federation was recognized by the Kenneth Allen Award. The award was retired in 1948.

Recipients of this award have been:

*1943*

| *Name* | *Member Association* |
|---|---|
| Harry Thornton Calvert | I. S. P. (England) |
| Edward F. Eldridge | Michigan |

| | |
|---|---|
| John Kurtz Hoskins | Federal |
| Fred Merryfield | Pacific Northwest |
| Edward P. Molitor | New Jersey |
| Robert S. Phillips | North Carolina |
| Alfred Henry Weiters | Iowa |
| William Homer Wisely | Central States |

*1944*

| *Name* | *Member Association* |
|---|---|
| Albert Edward Berry | Canadian Institute |
| Van Porter Enloe | Georgia |
| Albert Legrand Genter | Maryland-Delaware |
| F. Wellington Gilcreas | New England |
| Charles A. Holmquist | New York |
| Dana Ewart Kepner | Rocky Mountain |
| Leon Benedict Reynolds | California |
| Wilson Waldo Towne | Dakota |

*1945*

| *Name* | *Member Association* |
|---|---|
| Howard Eugene Moses | Pennsylvania |
| George S. Russell | Missouri |
| Dario Travaini | Arizona |
| Frederick Holman Waring | Ohio |
| Joe Williamson, Jr. | Florida |
| Murray Alderson Wilson | Kansas |

*1946*

| *Name* | *Member Association* |
|---|---|
| E. J. M. Berg | Texas |
| Frank E. DeMartini | Federal |
| John R. Downes | New Jersey |
| Thomas J. Doyle | Michigan |
| John Henry Garner | I. S. P. (England) |
| Harold Benedict Gotaas | North Carolina |
| William P. Hughes | Pacific Northwest |
| Theodore R. Lovell | Iowa |
| George Martin | Central States |

*1947*

| *Name* | *Member Association* |
|---|---|
| William T. Knowlton | California |
| Floyd W. Pinney | Dakota |
| Gilbert R. Frith | Georgia |
| Clarence E. Keefer | Maryland-Delaware |
| Stuart E. Coburn | New England |
| Wellington Donaldson | New York |
| Henry J. Darcey | Oklahoma |
| Carroll H. Coberly | Rocky Mountain |
| William Storrie | Canadian Institute |
| William Merriam Cobleigh | Montana |

*1948*

| *Name* | *Member Association* |
|---|---|
| George W. Marx | Arizona |
| David Bryon Lee | Florida |
| William Q. Kehr | Missouri |
| F. Dean Stewart | Ohio |
| Francis deSales Friel | Pennsylvania |

### The Arthur Sidney Bedell Award

Established in 1948, the Arthur Sidney Bedell Award acknowledges extraordinary personal service to the Member Associations of the Federation. Each Member Association is privileged once in every three years to name one of its members to receive the award, which may be earned by organizational leadership, administrative service, membership activity, stimulation of technical functions, or similar participation. The award is named for the second President of the Federation, who exemplified its purpose by his long devotion and contribution to the affairs of the New York State Sewage Works Association.

Past recipients follow:

| *Name* | *Member Association* |
|---|---|
| Harry P. Croft | New Jersey |
| Victor Marcus Ehlers | Texas |
| R. Paul Farrell | Kentucky-Tennessee |
| Carl Edwin Green | Pacific Northwest |
| Frederick Leon McDonald | Arkansas |
| William McKinney Piatt | North Carolina |
| Walter Asa Sperry | Central States |
| Harold Warner Streeter | Federal |

### The William D. Hatfield Award

The William D. Hatfield Award recognizes outstanding annual sewage works operation reports. Following the 1946 award, the Board of Control authorized identical awards for outstanding annual reports prepared (1) for plants serving less than 10,000 population, (2) for plants serving populations of 10,000 to 100,000, and (3) for plants serving populations of more than 100,000 persons.

Recipients of this award have been:

*1946*

Walter M. Kunsch

*1947*

| *Name* | *Plant Population Classification* |
|---|---|
| F. E. Peterson | Under 10,000 |
| John R. Szymanski | 10,000 to 100,000 |
| Warren H. Sleeger and George J. Schroepfer | Over 100,000 |

*1948*

| *Name* | *Plant Population Classification* |
|---|---|
| F. E. Peterson | Under 10,000 |
| Thomas T. Hay | 10,000 to 100,000 |
| Kerwin L. Mick | Over 100,000 |

*1949*

| *Name* | *Plant Population Classification* |
|---|---|
| Russell D. Craun | Under 10,000 |
| George W. Martin | 10,000 to 100,000 |
| Thomas T. Hay (previous winner) | 10,000 to 100,000 |

### Membership Prizes

Prizes for membership activity in its various Member Associations have been awarded by the Federation since 1943. The following Member Associations have received these prizes:

| *Association* | *Year* |
|---|---|
| Federal Sewage Research Assn. and Central States Sewage Works Assn. | 1943 |
| Missouri Water and Sewerage Conf. and Central States Sewage Works Assn. | 1944 |
| Arizona Sewage and Water Works Assn. and Canadian Institute on Sewage and Sanitation | 1945 |
| Oklahoma Water and Sewage Conf. and Canadian Institute on Sewage and Sanitation | 1946 |
| Institute of Sewage Purification (Eng.) and Arkansas Water and Sewage Conference | 1947 |
| Pennsylvania Sewage and Industrial Wastes Association and West Virginia Sewage and Industrial Wastes Association | 1948 |
| Ohio Conference on Sewage and Industrial Wastes and Alabama Water and Sewage Association | 1949 |

### Quarter Century Operators Club

The Quarter Century Operators Club is an informal group comprising Active or Corporate Members of any Member Association who had been engaged in sewage treatment works operation, on a full-time resident basis, twenty-five years prior to the date of their admission into the Club. The Club was created in 1941 under the sponsorship of Frank Woodbury Jones, who serves as its registrar. The roster:

Charles C. Agar
Reuben A. Anderson
Harry M. Beaumont
E. Sherman Chase
Stuart E. Coburn
Morris M. Cohn
Rodney E. Cook
Earl Devendorf
John R. Downes
* Almon L. Fales
Harry M. Freeburn
Arnold H. Goodman
William P. Gyatt
Wm. C. Hamm
William D. Hatfield
* Charles C. Hommon
Frank W. Jones
Harry J. Krum
Roy S. Lanpher
George C. Behnke
Julius W. Bugbee
Raymond G. Case
John V. Lewis
George S. Long
C. D. McGuire
* Paul Mollitor, Sr.
Arthur H. Niles
I. H. Nevitt
John R. Palmer
Wm. M. Piatt
Wm. A. Ryan
Theodore C. Schaetzle
Glenn Searls
John S. Simmerman
H. W. Streeter
S. L. Tolman
Edmund B. Wagner
Charles E. Wheeler, Jr.

* Deceased.

## ANNUAL MEETINGS AND CONVENTIONS

| *Annual Meeting Number* | *Location* | *Date* |
|---|---|---|
| 1 | Chicago, Illinois † | October 16, 1928 |
| 2 | New York, New York † | January 18, 1929 |
| 3 | New York, New York † | January 14, 1930 |
| 4 | New York, New York † | January 22, 1931 |
| 5 | New York, New York † | January 22, 1932 |
| 6 | New York, New York † | January 19, 1933 |
| 7 | New York, New York † | January 18, 1934 |
| 8 | New York, New York † | January 18, 1935 |
| 9 | New York, New York † | January 16, 1936 |
| 10 | New York, New York † | January 22, 1937 |
| 11 | New York, New York † | January 21, 1938 |
| 12 | New York, New York † | January 20, 1939 |
| 13 | New York, New York † | January 18, 1940 |
| | Chicago, Illinois ‡ | October 3–5, 1940 |
| 14 | New York, New York † | January 15, 1941 |
| | New York, New York ‡ | October 9–11, 1941 |
| 15 | Cleveland, Ohio § | October 22–24, 1942 |
| 16 | Chicago, Illinois § | October 21–23, 1943 |
| 17 | Pittsburgh, Pa. § | October 12–14, 1944 |
| 18 | Chicago, Illinois † | October 17–18, 1945 |
| 19 | Toronto, Ont., Can. § | October 7–9, 1946 |
| 20 | Philadelphia, Pa. † | October 10, 1947 |
| | San Francisco, Calif.‡ | July 21–24, 1947 |
| 21 | Detroit, Mich.§ | October 18–21, 1948 |
| 22 | Boston, Mass. § | October 17–20, 1949 |

## DIRECTORY OF COMMITTEES

### 1949–50

### Constitutional Committees

(*See Article VI of By-laws*)

EXECUTIVE COMMITTEE OF THE BOARD OF CONTROL

A. H. Niles, *Chairman*

R. S. Rankin
F. L. Flood
L. M. Fisher
R. D. Pomeroy
V. M. Ehlers
R. E. Fuhrman

PUBLICATIONS COMMITTEE

The Publications Committee arranges the technical programs for the annual conventions of the Federation and has general supervision of all publications of the Federation.

F. W. Gilcreas, *Chairman*

J. E. Cooper
Rolf Eliassen
B. M. McDill
F. W. Mohlman
W. H. Wisely

† Annual business meeting of Board of Control.
‡ Convention of membership-at-large.
§ Annual business meeting of Board of Control and convention of membership-at-large.

### Organization Committee

The Organization Committee examines and reports to the Board on applications for membership in the Federation and endeavors to encourage the formation of new regional associations or conferences eligible for membership.

Earnest Boyce, *Chairman*

C. R. Compton
R. H. Suttie

### Sewage Works Practice Committee

The Sewage Works Practice Committee reviews and directs for publication any resolution, report, or publication which establishes professional or technical standards in the name of the Federation.

Morris M. Cohn, *Chairman*

Norval E. Anderson
D. E. Bloodgood
R. F. Brown
G. P. Edwards
F. W. Gilcreas
K. V. Hill
C. E. Keefer
C. W. Klassen
L. W. Van Kleeck
Kerwin L. Mick
F. W. Mohlman
A. H. Niles
Langdon Pearse
Willem Rudolfs
F. M. Veatch
W. H. Wisely

*Subcommittee on Use of Sludge as Fertilizer*

This subcommittee of the Sewage Works Practice Committee was assigned to compile a manual of practice on "Utilization of Sewage Sludge as Fertilizer." The assignment has been completed and Manual of Practice No. 2 was published under the above title in November, 1946.

A. H. Niles, *Co-Chairman*

Langdon Pearse, *Co-Chairman*

F. W. Gilcreas
F. W. Mohlman
Willem Rudolfs
T. C. Schaetzle
L. W. Van Kleeck
W. H. Wisely

*Subcommittee on Occupational Hazards*

This subcommittee of the Sewage Works Practice Committee has been assigned to compile a Manual of Practice on "Occupational Hazards in the Operation of Sewage Works." The manual has been completed and was distributed to the membership in December, 1944.

L. W. Van Kleeck, *Chairman*

S. H. Ash
Reuben F. Brown
Joseph Doman
Fred R. Ingram
L. L. Langford
L. E. West

*Subcommittee on Air Diffusion*

This subcommittee of the Sewage Works Practice Committee has been charged with the duty of producing a Manual of Practice on "Air Diffusion in Sewage Treatment." The final draft of the manual is under review.

Norval E. Anderson, *Chairman*

A. J. Beck
G. P. Edwards
C. T. Mickle
W. F. Schade
C. B. Townend
J. J. Wirts

*Subcommittee on Sewer Maintenance*

This subcommittee of the Sewage Works Practice Committee has been directed to develop a Manual of Practice on "Maintenance of Sewers and Appurtenant Structures." The first draft of the manual is in preparation.

R. F. Brown, *Chairman*

Thos. B. Garry
W. H. Brown, Jr.
G. E. Finck
Grant Olewiler
R. L. Patterson
Henry Fitch
B. H. Grout
Roy E. Phillips
Richard Pomeroy
Robert P. Shea
John H. Brooks, Jr.
Forest Weber

*Subcommittee on Chlorination of Sewage*

This subcommittee of the Sewage Works Practice Committee has been assigned the development of a Manual of Practice on "The Use of Chlorine in Sewage Treatment." The manual is in a late stage of preparation.

F. W. Gilcreas, *Chairman*

N. S. Chamberlain
A. E. Griffin
H. A. Faber

*Subcommittee on Standardization of Units*

This subcommittee of the Sewage Works Practice Committee has been assigned to develop an approved schedule of units to be used in the reporting of plant operation and laboratory data. A committee of about forty members is at work.

Willem Rudolfs, *Chairman*

*Subcommittee on Trickling Filters*

This subcommittee of the Sewage Works Practice Committee is engaged in the development of a Manual of Practice to be entitled "Trickling Filters—Their Characteristics and Loadings."

Kenneth V. Hill, *Chairman*

B. F. Hatch
W. S. Mahlie
Wm. E. Stanley

*Subcommittee on Sewer Ordinances*

This subcommittee of the Sewage Works Practice Committee has been assigned the preparation of a Manual of Practice concerning the regulation and control of the usage of public sewers. Distribution of the completed manual was begun in September, 1949.

D. E. Bloodgood, *Chairman*

H. E. Babbitt
Fred J. Biele
R. F. Brown
M. M. Cohn
Charles A. Davis
C. E. Keefer
A. F. Lehman
A. H. Niles
B. A. Poole
J. L. Quinn
C. L. Siebert

*Subcommittee on Sewage Works Accounting*

This sewage works practice subcommittee was created in 1946 for the purpose of developing a manual of practice on accounting procedures for municipal sewage works functions. Mimeographed copies of the manual in tentative form were made available for purchase in April, 1949.

F. M. Veatch, *Chairman*

| | |
|---|---|
| G. J. Beiswanger | E. A. Farmer |
| Charles A. Davis | K. K. Wallace |
| Alfred A. Estrada | S. I. Zack |

*Subcommittee on Paints and Protective Coatings*

This sewage works practice subcommittee has the function of assembling experience and data on paints and protective coatings used in sewage works, to be presented with recommendations in the form of a manual. The subcommittee was created in 1946 and is now collecting data on this subject.

Kerwin L. Mick, *Chairman*

| | |
|---|---|
| Virgil Anderson | F. W. Pinney |
| W. D. Hatfield | Walter A. Sperry |
| J. W. Johnson | M. L. Robbins |
| W. T. McClenahan | |

RESEARCH COMMITTEE

The Research Committee has the function of stimulating research work among the various Member Associations, and of cooperating with other organizations in the promotion of research.

Willem Rudolfs, *Chairman*

| | |
|---|---|
| H. E. Babbitt | F. W. Mohlman |
| D. E. Bloodgood | H. E. Orford |
| G. P. Edwards | C. C. Ruchhoft |
| H. A. Faber | N. H. Sanborn |
| H. W. Gehm | C. N. Sawyer |
| A. L. Genter | L. R. Setter |
| H. Heukelekian | H. A. Trebler |
| R. D. Hoak | L. W. Van Kleeck |
| H. J. Miles | |

*Subcommittee on Toxicity of Industrial Wastes*

This subcommittee of the Research Committee is functioning in three sections:

Section I. Critical review of literature; Willem Rudolfs, *Chairman*, C. E. Barnes, P. Doudoroff, G. P. Edwards, H. Heukelekian, F. W. Kittrell, C. E. Renn and R. F. Weston.

Section II. Development of methods for toxicity determinations on wastes; J. A. McCarthy, *Chairman*, S. E. Coburn, G. P. Edwards, H. Heukelekian, E. Hurwitz, R. S. Ingols, C. C. Ruchhoft, W. W. Sanderson, C. M. Sawyer and R. F. Weston.

Section III. Development and standardization of bio-assay methods; P. Doudoroff, *Chairman*.

FINANCE COMMITTEE

The Finance Committee develops the annual operating budget of the Federation and affords guidance to the Board of Control in financial affairs.

W. J. Orchard, *Chairman*

| | |
|---|---|
| V. M. Ehlers | A. H. Niles |

## Special Committees

COMMITTEE ON AWARDS

The Committee on Awards was created by the Board of Control on October 11, 1941. Functions of the committee are to advise the Board on matters of award pro-

cedures and to make recommendations as to the annual winners of the Eddy, Gascoigne and Emerson Awards.

L. S. Kraus, *Chairman*

H. B. Gotaas G. A. Rohlich

### Honorary Membership Committee

Authorized by the Board of Control on October 24, 1942, this committee comprises the President and four latest, living Past Presidents with the senior Past President as chairman. The committee reviews nominations for election to the grade of Honorary Member and makes recommendations to the Board on such nominations.

J. K. Hoskins, *Chairman*

V. M. Ehlers A. H. Niles
F. S. Friel G. S. Russell

### Operation Reports Committee

The Operation Reports Committee was created by the Board of Control on October 11, 1941, to provide for Federation recognition of outstanding operation reports. The committee now administers the annual William D. Hatfield Award.

A. F. Dappert, *Chairman*

L. E. West G. A. Hall

### Operator's Qualifications Committee

Authorized by the Board of Control on October 11, 1941, the Operator's Qualifications Committee is assigned to "establish minimal qualifications for operators of various classes of treatment works." The committee also has the duty of collecting and compiling data on present procedures in the licensing and certification of operators, for reference to Member Associations.

L. W. Van Kleeck, *Chairman*

Benjamin Benas T. C. Schaetzle

### Industrial Wastes Committee

The Industrial Wastes Committee was created by the Board of Control on October 23, 1943, for the purpose of developing interest in this important field and to direct a program whereby the Federation may be of service in industrial waste problems.

F. W. Mohlman, *Chairman*

R. R. Balmer R. W. Hess
D. E. Bloodgood L. F. Oeming
H. W. Gehm Wm. S. Wise
W. B. Hart

### Nominating Committee

The special Nominating Committee was created by the Board of Control on October 9, 1946, to function in an advisory capacity to the Election Committee. The Nominating Committee is to comprise the last five living Past Presidents, with the senior Past President as chairman.

A. E. Berry, *Chairman*

V. M. Ehlers G. S. Russell
J. K. Hoskins F. S. Friel

### Quarter Century Operators Club Committee

The special Quarter Century Operators Club Committee was created by the Board of Control on October 9, 1946. It is the function of this Committee to establish eligibility requirements, process membership applications, maintain the roster and supervise the activities of the Quarter Century Operators Club.

Frank W. Jones, *Chairman*

Stuart E. Coburn — Harold W. Streeter

### Legislative Analysis Committee

The Legislative Analysis Committee was created by the Board of Control on October 17, 1945, to study legislation pertinent to the interests of the Federation and to serve the Board in advisory capacity.

David B. Lee, *Chairman*

C. E. Schwob — L. D. Matter
C. I. Sterling — R. L. Winget

### Constitution and By-Laws Committee

The Constitution and By-laws Committee was created by the Board of Control on October 10, 1947, to review and develop recommendations for the amendment of the Constitution and By-laws of the Federation as may be deemed advisable under changing conditions.

C. A. Emerson, *Chairman*

F. S. Friel — W. J. Orchard
F. W. Gilcreas — G. S. Russell

### Committee on Emergency Planning

Created in 1948, the Committee on Emergency Planning is the medium of Federation cooperation with Federal agencies and others in matters pertaining to sanitation requirements and practices in the event of national emergency or disaster.

C. W. Klassen, *Chairman*

M. R. Golly — David B. Lee
W. A. Hardenbergh — B. A. Poole

### Committee on Sewer Revenue Rates and Rate Structures

The Committee on Sewer Revenue Rates and Rate Structures was created by the Board of Control in 1948 to study and advise the Board on matters of Federation policy appertaining to sewer revenue financing procedures.

G. J. Schroepfer, *Chairman*

H. R. Green — M. W. Tatlock
W. E. Stanley — F. M. Veatch

## Joint Committees With Other Associations

### Committee on Standard Methods of Sewage and Industrial Wastes Analysis

Created by the Board of Control on January 22, 1931, the Committee on Standard Methods of Sewage and Industrial Wastes Analysis has functioned with similar committees of the American Water Works Association and American Public Health Association in the production of the laboratory manual *Standard Methods for the Examina-*

*tion of Water and Sewage.* In 1947 the Federation became a joint publisher of this book with the above associations. The committee is presently engaged in a comprehensive research project on analytical methods, which project is being financed by a grant made through the National Institute of Health.

W. D. Hatfield, *Chairman*

G. E. Symons
S. E. Coburn
D. E. Bloodgood
A. J. Fischer
W. W. Sanderson
R. D. Hoak
Keeno Fraschino
W. S. Mahlie
A. M. Buswell
F. W. Kittrell
C. N. Sawyer
H. Heukelekian
G. P. Edwards
E. W. Moore
M. Starr Nichols
Richard Pomeroy
C. C. Ruehhoft
Willem Rudolfs
R. F. Weston
M. G. Mellon
L. K. Herndon

### Committee on Water and Sewage Works Development

The Committee on Water and Sewage Works Development was organized in 1943 to promote the planning of water and sewage works and to encourage the inclusion of such projects in postwar planning programs. The committee, temporarily inactivated, comprises representatives of the Water and Sewage Works Manufacturers Association, American Water Works Association, New England Water Works Association and the Federation of Sewage Works Associations. Federation representatives are:

C. A. Emerson
G. J. Schroepfer

## Special Convention Committees

### Convention Management Committee

The function of this committee is to supervise details of the management of the Annual Meetings of the Federation.

W. J. Orchard, *Chairman*

A. T. Clark
L. H. Enslow
C. E. Keefer
W. H. Wisely

### Meeting Place Committee

This committee reviews invitations received for the Annual Meetings of the Federation and makes recommendations to the Board of Control in regard to the time and place of such meetings.

A. H. Niles, *Chairman*

R. E. Fuhrman
V. M. Ehlers
W. H. Wisely
R. F. Hayes
W. F. Rockwell
A. T. Clark

### Publicity and Attendance Committee

The function of this committee is to prepare publicity releases in connection with the Annual Meetings of the Federation and to direct the distribution of such material.

L. H. Enslow, *Chairman*

M. M. Cohn
W. A. Hardenbergh

## SUMMARY OF MEMBERSHIP

*(As at December 31, 1949)*

### Federation Members

| | |
|---|---|
| Honorary Members | 9 |
| Associate Members | 76 |
| Member Associations | 36 |
| Active Members | 5131 |
| Corporate Members | 78 |

### Net Membership of Member Associations *

| Member Association | Active | Honorary | Corporate | Total |
|---|---|---|---|---|
| Alabama | 29 | — | 3 | 32 |
| Argentina | — | — | — | — |
| Arizona | 32 | — | 6 | 38 |
| Arkansas | 48 | — | — | 48 |
| California | 395 | 1 | — | 396 |
| Canadian Inst. | 353 | — | — | 353 |
| Central States | 546 | 2 | 16 | 564 |
| Dakota | 53 | — | — | 53 |
| Federal | 134 | — | — | 134 |
| Florida | 109 | — | — | 109 |
| Georgia | 60 | — | — | 60 |
| Iowa | 115 | — | — | 115 |
| ISE (Eng.) | 36 | — | — | 36 |
| ISP (Eng.) | 233 | — | — | 233 |
| Kansas | 39 | — | — | 39 |
| Kentucky-Tennessee | 127 | — | 5 | 132 |
| Louisiana | 2 | — | — | 2 |
| Maryland-Delaware | 49 | — | — | 49 |
| Michigan | 241 | — | 2 | 243 |
| Missouri | 53 | — | — | 53 |
| Montana | 38 | — | 5 | 43 |
| New England | 285 | 2 | — | 287 |
| New Jersey | 143 | 1 | — | 144 |
| New York | 590 | 1 | 3 | 594 |
| North Carolina | 89 | — | — | 89 |
| Ohio | 306 | — | 8 | 314 |
| Oklahoma | 36 | — | 36 | 36 |
| Pacific Northwest | 182 | — | — | 182 |
| Pennsylvania | 375 | 2 | 18 | 395 |
| Puerto Rico | 24 | — | 1 | 25 |
| Rocky Mountain | 72 | — | — | 72 |
| South Carolina | — | — | — | — |
| Swiss | 13 | — | — | 13 |
| Texas | 123 | — | — | 123 |
| Virginia | 91 | — | 9 | 100 |
| West Virginia | 110 | — | 2 | 112 |
| Totals | 5131 | 9 | 78 | 5218 |

* Not including Dual Members.

# Directory of Members

## MEMBER ASSOCIATIONS

**Alabama Water and Sewage Association** (Affiliated 1948).

Territory: State of Alabama.
*President:* George H. Godwin; *Vice-President:* John Staleup; *Director:* R. C. Barton; *Treasurer:* G. H. Dunstan; *Secretary:* Alex O. Taylor, Box 69, Auburn, Ala.

**Argentina Society of Engineers, Sanitary Engineering Division** (Affiliated 1936).

Territory: Republic of Argentina.
*FSWA Contact Member:* E. B. Besselievre, The Dorr Co., 570 Lexington Ave., New York, N. Y.

**Arizona Sewage and Water Works Association—Sewage Works Section** (Affiliated 1928).

Territory: State of Arizona.
*President:* A. Anton Frederickson; *First Vice-President:* George M. Marx; *Second Vice-President:* John Hoover; *Director:* Harold Yost; *Secretary-Treasurer:* Mrs. Helen Rotthaus, c/o Sanitary Engineering Div., State Dept. of Health, Capitol Bldg., Phoenix, Ariz.

**Arkansas Water and Sewage Conference—Sewage Works Section** (Affiliated 1946).

Territory: State of Arkansas.
*Chairman:* Neal B. Thayer; *Vice-Chairman:* Fay Peer; *Director:* B. W. Dees; *Secretary-Treasurer:* Harrison Hale, University of Arkansas, 118 Chemistry Bldg., Fayetteville, Ark.

**California Sewage Works Association** (Affiliated 1928).

Territory: State of California.
*President:* Raymond R. Ribal; *First Vice-President:* Frederick G. Nelson; *Second Vice-President:* Harold B. Gotaas; *Director:* Richard Pomeroy; *Secretary-Treasurer:* Lawrence H. Cook, Box 696, Menlo Park, Calif.

**Canadian Institute on Sewage and Sanitation** (Affiliated 1933).

Territory: Dominion of Canada.
*President:* L. G. McNeice; *Vice-President:* D. A. R. McCannel; *Director:* William Storrie; *Secretary-Treasurer:* A. E. Berry, Ontario Dept. of Health, Parliament Buildings, Toronto, Ont., Can.

**Central States Sewage Works Association** (Affiliated 1928).

Territory: States of Illinois, Indiana, Wisconsin, and Minnesota.
*President:* L. S. Kraus; *First Vice-President:* H. T. Rudgal; *Second Vice-President:* M. L. Robins; *Third Vice-President:* W. W. Mathews; *Director:* George Martin; *Secretary-Treasurer:* Paul W. Reed, c/o U. S. Public Health Service, 69 W. Washington St., Chicago 2, Ill.

**Dakota Water and Sewage Works Conference—Sewage Works Sections** (Affiliated 1936).

**North Dakota Section.**

Territory: State of North Dakota.
*President:* A. F. Hulteng; *Vice-President:* H. H. Behlmer; *Director:* Roy G. Spieker; *Secretary-Treasurer:* Jerome H. Svore, c/o State Dept. of Health, Bismarck, N. Dak.

**South Dakota Section.**

Territory: State of South Dakota.
*President:* C. B. Madison; *Vice-President:* Wallace Johnson; *Director:* Roy G. Spieker; *Secretary-Treasurer:* Charles E. Carl, c/o State Board of Health, Pierre, S. Dak.

**Federal Sewage Research Association** (Affiliated 1930).

Territory: Federal employees wherever stationed.
*President:* Wm. H. Cary, Jr.; *Vice-President:* Gordon E. McCallum; *Director:* Robert N. Clark; *Secretary-Treasurer:* Leonard B. Dworsky, c/o Div. of Water Pollution Control, U. S. Public Health Service, Washington 25, D. C.

**Florida Sewage Works Association** (Affiliated 1941).

Territory: State of Florida.
*President:* S. K. Keller; *Vice-President:* W. J. Parks; *Director:* B. F. Borden; *Secretary-Treasurer:* Perry M. Teeple, P. O. Box 210, Jacksonville, Fla.

**Georgia Water and Sewage Association—Sewage Works Section** (Affiliated 1936).

Territory: State of Georgia.
*President:* Clyde Angle; *Vice-President:* Van P. Enloe; *Director:* Gilbert R. Frith; *Secretary-Treasurer:* L. E. Waller, Rte. 12, Box 246, Atlanta, Ga.

**Institution of Sanitary Engineers—England** (Affiliated 1932).

Territory: British Empire.
*President:* N. Campbell-Little; *Director:* Gordon S. McDonald; *Secretary:* Earnest V. Balsom, 118 Victoria St., Westminster, S. W. 1, London, England.

**Institute of Sewage Purification—England** (Affiliated 1932).

Territory: British Empire.
*President:* Clarence Jepson; *Vice-President:* C. B. Townend; *Director:* W. F. Freeborn; *Treasurer:* H. Booth; *FSWA Contact Member:* Martin Lovett, 206 Bradford Rd., Wakefield, Yorkshire, England.

**Iowa Sewage Works Association** (Affiliated 1928).

Territory: State of Iowa.
*President:* Paul Bolton; *Vice-President:* Carl Borland; *Director:* J. L. Strelow; *Secretary-Treasurer:* Leo Holtcamp, P. O. Box 310, Webster City, Ia.

**Kansas Sewage Works Association** (Affiliated 1935).

Territory: State of Kansas.
*Chairman:* Roy Binder; *Vice-Chairman:* D. B. Kissinger; *Director:* E. F. Miltner; *Secretary-Treasurer:* Dwight F. Metzler, c/o State Board of Health, Marvin Hall, University of Kansas, Lawrence, Kans.

**Kentucky-Tennessee Industrial Wastes and Sewage Works Association** (Affiliated 1946).

Territory: States of Kentucky and Tennessee.
*Chairman:* S. Leary Jones; *Vice-Chairman:* G. R. Watkins; *Director:* Maurice L. Miller; *Secretary-Treasurer:* R. P. Farrell, 420 Sixth Ave., N., Nashville 3, Tenn.

**Louisiana Conference on Water Supply and Sewerage** (Affiliated 1949).

Territory: State of Louisiana.
*Chairman:* Joseph Cefalu; *Vice-Chairman:* Ben S. Graves; *Director:* S. S. Crawford; *Secretary-Treasurer:* Dan L. Winters, c/o Gulf Public Service Co., Inc., New Iberia, La.

**Maryland-Delaware Water and Sewerage Association—Sewage Works Section** (Affiliated 1928).

Territory: States of Maryland and Delaware.
*President:* A. A. Bailey; *First Vice-President:* R. E. Fuhrman; *Second Vice-President:* L. E. McClung; *Director:* C. E. Keefer; *Secretary-Treasurer:* W. M. Bingley, 2411 N. Charles St., Baltimore 18, Md.

**Michigan Sewage Works Association** (Affiliated 1930).

Territory: State of Michigan.
*President:* G. E. Hubbell; *Vice-President:* D. W. Granger; *Director:* L. F. Oeming; *Secretary-Treasurer:* Donald M. Pierce, State Dept. of Health, Room 334, Administration Bldg., Lansing 4, Mich.

**Missouri Water and Sewerage Conference—Sewage Works Section** (Affiliated 1929).

Territory: State of Missouri.
*Chairman:* Herbert O. Hartung; *Vice-Chairman:* Frank Thierfelder; *Director:* Allan H. Wymore; *Secretary-Treasurer:* Warren A. Kramer, c/o State Office Bldg., Jefferson City, Mo.

**Montana Sewage Works Association** (Affiliated 1944).

Territory: State of Montana.
*Chairman:* Chet Eyer; *Vice-Chairman:* Kurt Wiel; *Director:* K. L. Chrysler; *Secretary-Treasurer:* H. B. Foote, Div. of San. Eng., State Board of Health, Helena, Mont.

**New England Sewage Works Association** (Affiliated 1929).

Territory: States of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island.
*President:* Ralph W. Horne; *First Vice-President:* William S. Wise; *Second Vice-President:* E. Sherman Chase; *Director:* F. L. Flood; *Secretary-Treasurer:* Walter E. Merrill, c/o State Dept. of Health, 511A State House, Boston, Mass.

**New Jersey Sewage Works Association** (Affiliated 1942).

Territory: State of New Jersey.
*President:* John Struss; *Vice-President:* Sol. Seid; *Director:* L. J. Fontenelli; *Secretary-Treasurer:* Michael S. Kachorsky, Box 283, Manville, N. J.

**New York Sewage and Industrial Wastes Association** (Affiliated 1930).

Territory: State of New York.
*President:* John W. Johnson; *Vice-President:* J. M. MacCrea; *Director:* G. E. Symons; *Treasurer:* J. C. Brigham; *Secretary:* Ralph C. Sweeney, c/o State Dept. of Health, 615 Commerce Bldg., 119 E. Main St., Rochester, N. Y.

**North Carolina Sewage Works Association** (Affiliated 1929).

Territory: State of North Carolina.
*Chairman:* E. R. Tull; *Vice-Chairman:* W. W. Atkins; *Director:* Robert S. Phillips; *Secretary-Treasurer:* E. C. Hubbard, c/o State Board of Health, Raleigh, N. C.

**Ohio Sewage and Industrial Wastes Treatment Conference** (Affiliated 1932).

Territory: State of Ohio.
*Chairman:* W. R. Bowman; *First Vice-Chairman:* H. S. Kline; *Second Vice-Chairman:* W. E. Gerdel; *Director:* B. M. McDill; *Secretary-Treasurer:* G. A. Hall; *Acting Secretary-Treasurer:* J. E. Richards, 302 Departments Bldg., Columbus 15, Ohio.

**Oklahoma Water, Sewage and Industrial Wastes Conference—Sewage Works Section** (Affiliated 1929).

Territory: State of Oklahoma.
*President:* Grover L. Morris; *Vice-President:* R. B. Riddle; *Director:* Frank S. Taylor; *Secretary-Treasurer:* H. J. Darcey, State Dept. of Health, Oklahoma City 5, Okla.

**Pacific Northwest Sewage Works Association** (Affiliated 1933).

Territory: States of Washington, Oregon, and Idaho.
*President:* Emil C. Jensen; *First Vice-President:* W. P. McNamara; *Second Vice-President:* Wm. W. Tinniswood; *Director:* C. M. Howard; *Secretary-Treasurer:* Wm. P. Hughes, City Engineer's Office, City Hall, Lewiston, Idaho.

**Pennsylvania Sewage and Industrial Wastes Association** (Affiliated 1928).

Territory: State of Pennsylvania.
*President:* E. T. Roetman; *First Vice-President:* John Campbell; *Second Vice-President:* Charles Ruening; *Director:* C. H. Young; *Secretary-Treasurer:* B. S. Bush, c/o Pennsylvania Dept. of Health, Kirby Health Center, Wilkes-Barre, Pa.

**Puerto Rico Water and Sewage Works Association** (Affiliated 1947).

Territory: Puerto Rico.
*President:* Manuel Vinas Sarba; *Vice-President:* Wm. C. Hill; *Director:* Alberto Hernandez; *Secretary-Treasurer:* Alvah R. Pierce, c/o Puerto Rico Aqueduct & Sewer Service, Box 2832, San Juan 12, P. R.

**Rocky Mountain Sewage Works Association** (Affiliated 1947).

Territory: States of Wyoming, Colorado, and New Mexico.
*President:* Carl M. Bennett; *Vice-President:* Sam Gass; *Director:* L. O. Williams; *Secretary-Treasurer:* Carroll H. Coberly, Room 329, 1441 Welton St., Denver 2, Colo.

**South Carolina Water and Sewage Works Association—Sewage Works Section** (Affiliated 1949).

Territory: State of South Carolina.
*President:* George A. Rhame; *Vice-President:* E. D. Fry; *Director:* George A. Rhame; *Secretary-Treasurer:* W. T. Linton, Wade Hampton Bldg., Columbia, S. C.

**Swiss Association of Water and Sewage Professionals** (Affiliated 1947).

Territory: Switzerland.
*President:* A. Kropf; *Vice-President:* H. Bachoffner; *Director:* Walter Dardel; *FSWA Contact Member:* Walter Dardel, Aarberg (Berne) Switzerland.

**Texas Water and Sewage Works Association—Sewage Works Section** (Affiliated 1928).

Territory: State of Texas.
*Chairman:* I. M. Dietz; *Vice-Chairman:* S. L. Allison; *Director:* J. H. Sorrells; *Assistant Secretary:* Mrs. E. H. Goodwin; *Secretary-Treasurer:* V. M. Ehlers, 501 W. 33rd St., Austin 2, Tex.

**Virginia Industrial Wastes and Sewage Works Association** (Affiliated 1947).

Territory: State of Virginia.
*President:* Bryant W. Strother; *Vice-President:* J. A. Rines; *Director:* L. L. Hedgepeth; *Secretary-Treasurer:* A. H. Paessler, 815 E. Franklin St., Richmond 19, Va.

**West Virginia Sewage and Industrial Wastes Association** (Affiliated 1947).

Territory: State of West Virginia.
*President:* Edward Shroyer; *First Vice-President:* D. V. Moses; *Second Vice-President:* H. W. Speiden; *Director:* H. D. Lyon; *Secretary-Treasurer:* R. G. McCall, Rm. 643, State Capitol Bldg., Charleston 5, W. Va.

## HONORARY MEMBERS

Bugbee, Julius W. (1942), 290 Massachusetts Ave., Providence, R. I.

Emerson, Charles A. (1941), Havens & Emerson, Woolworth Bldg., New York 7, N. Y.

Gilcreas, W. Wellington (1948), Asst. Dir., Div. of Labs. & Res., State Dept. of Health, New Scotland Ave., Albany 1, N. Y.

Hyde, Charles Gilman (1943), Cons. Engr., 2599 Buena Vista Way, Berkeley 8, Calif.

Mohlman, Dr. Floyd W. (1944), Dir., Div. of Labs., Chicago San. Dist., 910 S. Michigan Ave., Chicago 5, Ill.

Moses, Howard E. (1943), Chief San. Engr., State Dept. of Health, 1522 N. Second St., Harrisburg, Pa.

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## MEMBER ASSOCIATION MEETINGS

| *Association* | *Place* | *Time* |
|---|---|---|
| Texas Water and Sewage Works Association | College Station, Tex. | Mar. 12–16, 1950 |
| Louisiana Conference on Water Supply and Sewerage | Louisiana State University, Baton Rouge, La. | Mar. 15–17, 1950 |
| New Jersey Sewage Works Association | Stacy-Trent Hotel, Trenton, N. J. | Mar. 22–24, 1950 |
| Virginia Industrial Wastes and Sewage Works Association | Geo. Washington Hotel, Winchester, Va. | Mar. 30–31, 1950 |
| Arizona Sewage and Water Works Association | Safford, Ariz. | Mar. 31–Apr. 2, 1950 |
| Arkansas Water and Sewage Conference | Robinson Memorial Auditorium, Little Rock, Ark. | Apr. 17–19, 1950 |
| Kansas Sewage Works Association | Lamar Hotel, Salina, Kans. | Apr. 20–21, 1950 |
| Montana Sewage Works Association | Florence Hotel, Missoula, Mont. | Apr. 20, 1950 |
| Maryland-Delaware Water and Sewerage Association | Fort Cumberland Hotel, Cumberland, Md. | Apr. 27–28, 1950 |
| California Sewage Works Association | Lafayette Hotel, Long Beach, Calif. | May 3–6, 1950 |
| Pacific Northwest Sewage Works Association | Winthrop Hotel, Tacoma, Wash. | May 10, 1950 |
| Michigan Sewage Works Association | Park Place Hotel, Traverse City, Mich. | May 22–24, 1950 |
| New England Sewage Works Association | Hotel Sheraton, Worcester, Mass. | June 1, 1950 |
| Alabama Water and Sewage Association | Alabama Polytechnic Institute, Auburn, Ala. | June 6–8, 1950 |
| Central States Sewage Works Association | Indianapolis, Ind. | June 9–10, 1950 |
| New York Sewage and Industrial Wastes Association (Spring Meeting) | Hotel Jamestown, Jamestown, N. Y. | June 12–13, 1950 |
| Ohio Sewage and Industrial Wastes Treatment Conference | Gibson Hotel, Cincinnati, Ohio | June 28–30, 1950 |
| Pennsylvania Sewage and Industrial Wastes Association | Pennsylvania State College, State College, Pa. | Aug. 23–25, 1950 |
| Iowa Sewage Works Association | Hotel Blackhawk, Davenport, Ia. | Sept. 19–21, 1950 |
| Rocky Mountain Sewage Works Association | La Fonda Hotel, Santa Fe, N. Mex. | Sept. 27–29, 1950 |
| Missouri Water and Sewerage Conference | Sheraton Hotel, St. Louis, Mo. | Oct. 1–3, 1950 |
| **Federation of Sewage Works Associations** | **Hotel Statler, Washington, D. C.** | **Oct. 9–12, 1950** |
| North Carolina Sewage Works Association | Washington-Duke Hotel, Durham, N. C. | Nov. 13–15, 1950 |

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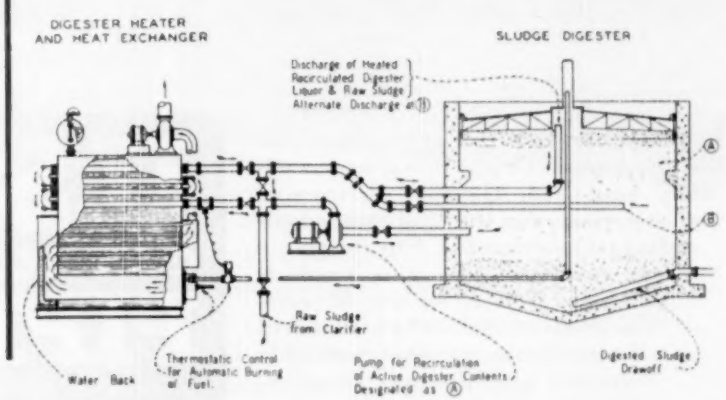
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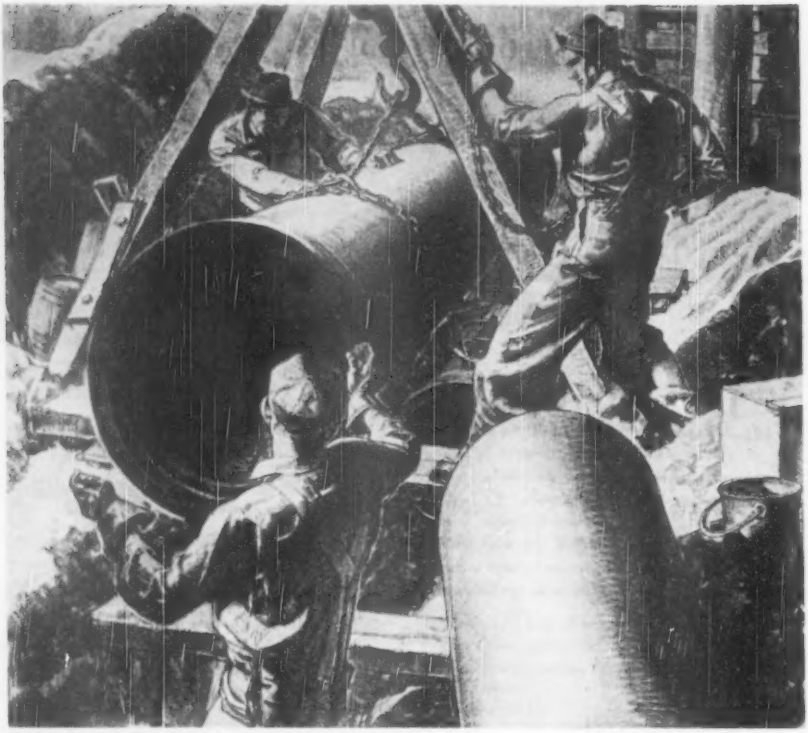

*Painted for U. S. Pipe & Foundry Co. by Dean Cornwell*

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**THE CHAPMAN VALVE MFG. CO.**

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# Less Infiltration

TRANSITE* SEWER PIPE offers two basic safeguards that minimize infiltration in sewer lines: *tighter* joints and *fewer* joints.

Transite's special sleeve-type joints make up tight and stay tight in service.

Its long 13-foot lengths reduce the number of joints in the system.

These safeguards cut down the volume usually allowed for infiltration, reducing sewage load on the treatment plant and conserving plant capacity for future needs. Where new treatment facilities are planned, this reduced infiltration may permit consideration of a smaller plant with resulting economies.

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Transite Sewer Pipe is made of asbestos, cement and silica by a special manufacturing process that employs steam curing to develop greater corrosion resistance and strength. It is available in four strength classes in sizes to 36", permitting selection of the pipe best suited to trench conditions, and frequently eliminating the need for concrete cradles.

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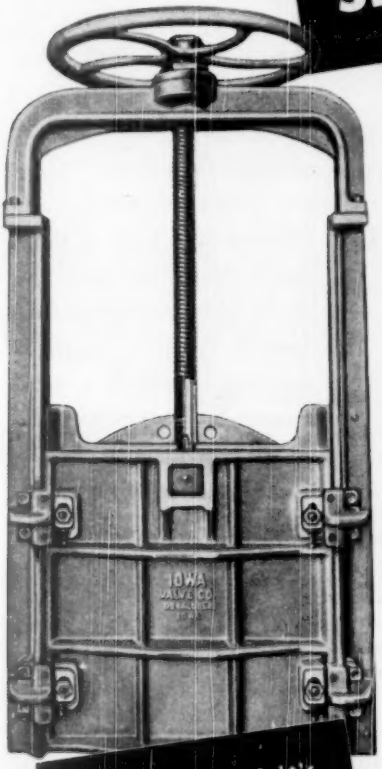
TRANSITE SEWER PIPE . . .

# 7 Reasons Why

## IOWA SLUICE GATES

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**5** Can be operated manually or equipped with cylinder or motor unit for hydraulic or electrical operation.

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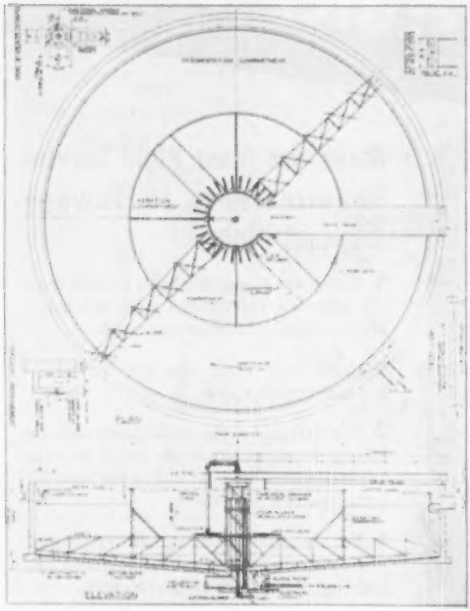
# *PROBLEM:*

*HIGH DEGREE OF PURIFICATION AT LOW COST*

# *Solution:*

# THE PROCESS OXIDATOR

***Engineers choose Process Oxidator for new sewage plant to help meet rigid state health requirements.***



General drawing of one of two Process Oxidators in series now being constructed at Oceanside, California. Consulting Engineers: Quinton Engineers Ltd. Contractor: Theodore Gregory.

A modern sewage plant designed to serve 20,000 people, is now under construction at Oceanside, California. Due to the location of the city's sewage collection system, the new plant is situated near a residential district. The California State Board of Health stated: "There shall be no noxious or offensive odors, gases or fumes of sewage . . . such as they may constitute a public nuisance." The Process Oxidator was chosen as the clarification unit that would answer this demand.

*(Patents Pending)*

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- Increased grease removal
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- Greater reduction in bio-chemical oxygen demand
- Elimination of odors by maintaining sewage in fresh condition
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**Investigate this new leader in economy and efficiency! Write to either address below for additional information. Process Engineers Inc. maintain a staff of specialized engineers who are glad to be of service.**

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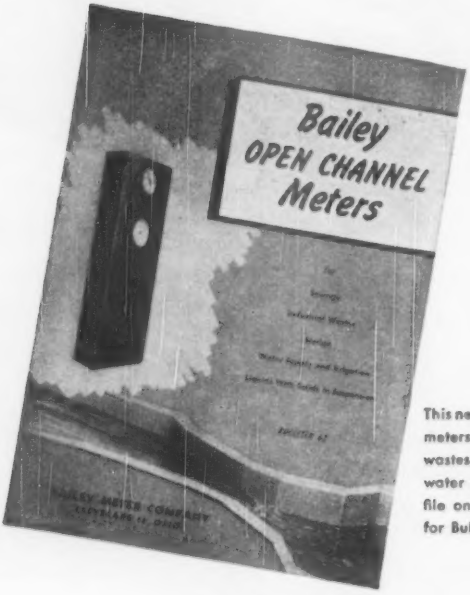


This new publication describing meters for sewage, industrial wastes, sludge and irrigation water should be part of your file on flow measurement. Ask for Bulletin 62.

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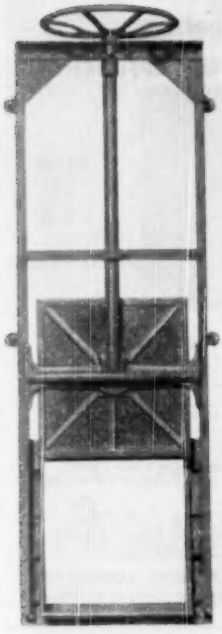

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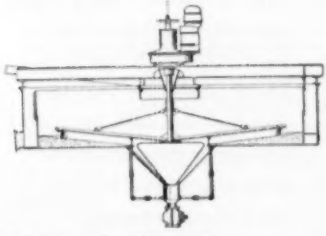

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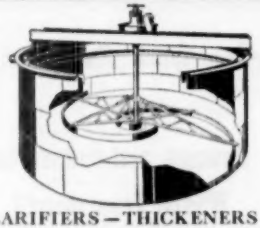

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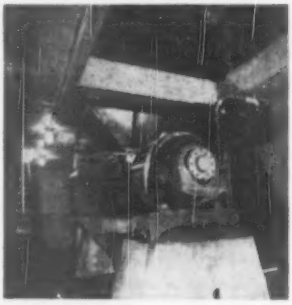

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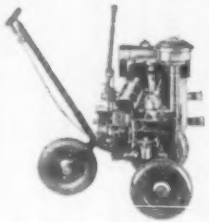

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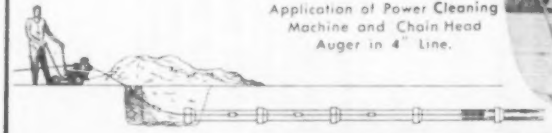

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## INDEX TO ADVERTISERS


| | Page |
|---|---|
| American Car and Foundry Company | 15 |
| Armco Drainage and Metal Products, Inc. | 30 |
| Bailey Meter Company | 40 |
| Bristol Company | 39 |
| Builders-Providence, Inc. | 3 |
| Cast Iron Pipe Research Association | 20 |
| Chain Belt Company | 14-15 |
| Chapman Valve Manufacturing Company | 23 |
| Chicago Pump Company | 1 |
| Dorr Company, The | 31 |
| Economy Pumps, Inc. | 4 |
| Electro Rust-Proofing Corp. (N. J.) | 26 |
| Everson Manufacturing Corporation | 38 |
| Flexible Sewer-Rod Equipment Company | 40 |
| Gruendler Crusher and Pulverizer Company | 35 |
| Hamilton-Thomas Corporation | 6 |
| Hardinge Company, Inc. | 37 |
| Infilco, Inc. | 11 |
| Iowa Valve Company | 27 |
| Jeffrey Manufacturing Company | 17 |
| Johns-Manville Corporation | 28 |
| Koppers Company, Inc. | 18 |
| Link-Belt Company | 8-9 |
| Magnetite Filter Corporation | 33 |
| National Clay Pipe Manufacturers, Inc. | 32 |
| Nichols Engineering and Research Corporation | 12 |
| Pacific Flush Tank Company | 33 |
| Process Engineers, Incorporated | 36 |
| Simplex Valve and Meter Company | 5 |
| Snow Intaketor Supply | 27 |
| Stewart, W. H., Inc. | 10 |
| Trickling Filter Floor Institute | 30 |
| U. S. Pipe and Foundry Company | 24 |
| Vapor Recovery Systems Company | 16 |
| Walker Process Equipment, Inc. | 31 |
| Wallace & Tiernan Co., Inc. | Back Cover |
| Wood Company, R. D. | 7 |
| Yeomans Brothers Company | 29 |


## DIRECTORY OF ENGINEERS, pp. 33-35


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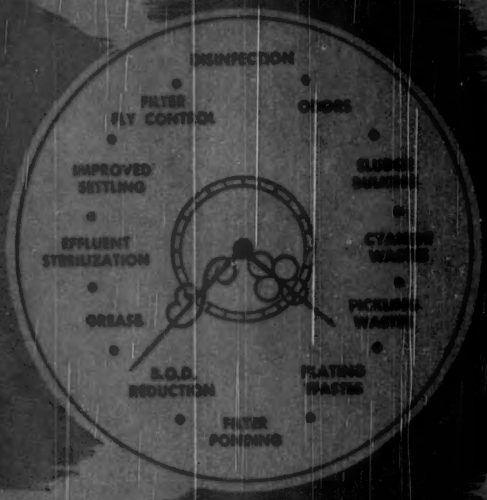

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